THE KINGDOM OF DUST

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POPULAR MECHANICS HANDBOOKS

THE KINGDOM OF DUST

Profusely Illustrated

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CONTENTS

The Kingdom of Dust

CHAPTER I

A BOUNDLESS DOMAIN

The vastness of the realm of dust. No limit to its reaches. All forms of matter, as well as all kinds of substances, represented. The extreme lightness of a particle of dust. Examples of the divisibility of matter. Fluorescein. The perfume of musk. How water becomes a conductor of electricity. The number of dust particles in a puff of cigarette smoke. An absolute vacuum an impossibility. The minute division of matter as shown by spectrum analysis. Deep-sea ooze. Dust is made up of every substance in the universe. The revelation of the sunbeam. Jagged blades of steel floating in air. Six tons of dust to the square mile in London. Effect of rain and snow on dust.

VAST is the kingdom of dust! Unlike terrestrial kingdoms, it knows no limits. No oceans mark its boundaries, no mountains hem it in. No parallels of latitude and longitude define its boundless area, nor can the farthermost stars in the infinitudes of space serve other than as twinkling outposts of a realm as vast as the universe itself. And what shall we say as to the component subjects of this kingdom? In number, form and variety, they transcend all conceptions of the human mind. In shape, they comprise every possible form.

In position, they include every substance that is material. In condition, they are solid, liquid, vaporous and gaseous.

They are with us in the quiet seclusion of our homes, in the busy streets and marts of commerce, on the sunlit crests of the snowy Himalayas, out on the silent prairies, mingled with the desert's shifting sands, amid the ice of the frozen Arctic. They come to us as tiny ambassadors from infinite space on the wings of flying ships, thousands of miles from land. They are enshrined in the beautiful snow crystals, and every drop of rain carries some of them from the upper reaches of the atmosphere.

Dust would not be possible were it not for the fact that matter is almost infinitely divisible. A coin that has been worn smooth in the course of years of passing from hand to hand is a good illustration of this fact. The wearing away was not done by any one hand, but by the touch of many. Every time a finger was placed upon it, no matter how slight the pressure, tiny particles of gold, or silver, or copper, as the case might be, were removed. No scales used by man could possibly weigh one of these tiny metallic particles of dust, nor could it be seen with the most powerful microscope. Nevertheless, it has length, breadth and thickness, and the removal of it, and of countless others, made the coin smooth and worn.

One sometimes sees an old piano whose ivory keys have deep grooves worn in them by fingers that have long since become subjects of the kingdom of dust. As in the case of the coin, every time the hard ivory was touched, no matter how lightly, small particles were dislodged to become errant soldiers in the great dust army.

Absolutely pure water will not permit an electrical current to traverse it. If a grain of salt be added to a hundred tons of perfectly pure water, the water becomes

Dust in a Porcelain Dish After Evaporating Snow, and a Clean Dish to Show Contrast

at once a conductor of electricity. It is supposed that the solitary grain of salt is divided into an almost infinite number of parts, and that each of these tiny motes of salt acts as a ferry by means of which the electric charge is enabled to cross the water. How extremely minute, then, must be these particles of salt, when a single grain will supply ferry service for a hundred tons of water, every cubic inch of which must necessarily contain hundreds of millions of salt particles.

A single grain of musk will perfume a room for years, penetrating every portion of it, and yet not lose sensibly in weight. As the sense of smell owes its inception to the bombardment of the olfactory nerve by small particles of the substance that gives rise to the perfume, we may gather some notion of the extreme minuteness of these particles.

It has been estimated that an average puff of smoke from a cigarette contains about four thousand millions of particles of dust. A single grain of indigo will give color to a ton of water, and, of course, every drop of this water must contain an immense number of ultra-microscopic particles of indigo. A few grains of fluorescein, a substance derived from a coal tar, will produce a distinct fluorescence, shining with a yellowish green light when strongly illuminated, in a hundred tons of water. To produce this result, the fluorescein must be divided into countless billions of particles.

Professor Warburg of Berlin is to be credited with an excellent illustration of the divisibility of matter. He succeeded in weighing the invisible layer of vapor which condenses on a dry plate in a moderately damp room, and calculated that the film of water dust thus deposited was 500,000 times thinner than the thinnest writing paper.

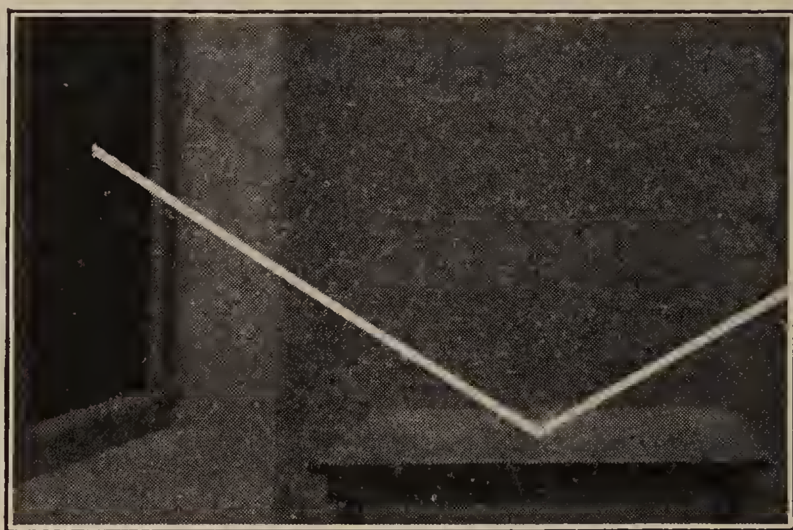
The process of division into extremely small particles goes on right under our eyes when we see a match flaming or a candle burning. Some of the carbon of each passes off into the atmosphere in particles so small that they will remain suspended for hours and even days before they finally settle down on the floor or other resting-place.

The ordinary incandescent electric-light bulb contains only about a millionth of an equal volume of the air such as we breathe. And yet the bulb is "full" of air, as the one-millionth that is left in the bulb after exhaustion by the vacuum pump occupies every part of it, and the tiny molecules are constantly whizzing to and fro in countless hordes—untold billions.

Still another and even more amazing illustration of the extreme divisibility of matter is shown in the case of the sodium coloration of a flame by the addition of a minute quantity of common table salt. A millionth part of a milligram (a milligram is 1/65 of a grain) of salt is amply sufficient to give a distinctly yellow coloration to a flame. To do this, this millionth of a milligram must have been vaporized into a gas containing trillions of particles of sodium.

Down at the bottom of the sea, under three miles of water, there lies a dust so fine that when it is rubbed between the fingers it enters the pores of the skin. This dust is the remains of the shells of plants and animals, such as Diatoms and Polycystines. It is estimated that one cubic inch of the ooze that covers the ocean floor contains the remains of forty thousand millions of organisms, each as distinct in its individuality as is an elephant, and possessing a structure that is as perfect, so far as its use is concerned, as is the structure of the human body.

Every conceivable substance enters into the composition of dust. In street dust may be found bits of iron and steel from the tires of wagons, horseshoes, and the nails of our own shoes; bits of leather from harness, fragments of wood, cotton, silk, stone, gold, silver, tin, clothing, wool, hair, animal excreta, various ores, paper, clay, sand, molds, bacteria—in fact, everything under the sun.



A Beam of Sunlight in a Darkened Room. The Reflection of the Light from the Dust Particles Makes It Visible to the Eye.

Sometimes this dust is so abundant that it fills the nostrils and irritates the delicate mucous membrane, so that one is forced to withdraw from its vicinity. At other times the dust is so imperceptible that one is almost certain there is none present. And yet the air is always full of it, as may be observed quite readily by noting the enormous number of dust motes in a sunbeam passing through a darkened room. Even in the quietest, cleanest room of our home, the sunbeam reveals the unnumbered myriads of everything material that is constantly floating in the atmosphere. Some of the dust finally subsides after floating for days or even months, and settles on the top of books, the mantel-shelf, picture-frames, chairs and other objects in the room, as the careful housewife is ready to testify.

A room left undisturbed for weeks at a time may

Dust Particles from a Pittsburg Schoolroom

appear to be free from dust, but let a beam of sunlight pass through it, and at once the multitudes of dancing, quivering, irregularly shaped particles flash into view. Every breath we take entombs thousands of these particles, even when every precaution is taken to lessen their number.

It has been calculated that in February, 1891, the amount of dust that fell on the house tops of the city of London amounted to six tons per square mile. It is not improbable, as will be shown, that this quantity, enormous as it is, is equaled or exceded in many of our

American cities, where coal, especially soft coal, is used as a fuel. Millions of dollars are spent annually as a tribute to this mighty Kingdom of Dust, in order that its unwelcome emissaries may take wings and fly away from our carpets, our curtains, our books, our windows and our streets. Unfortunately, they do not fly far, but settle down comfortably even after a stirring encounter with the dust cloth, broom or other cleansing agent. The fight against dust is a continuous one, and must be fought over and over again, the next hour or day or month, depending upon the energy of the dust-fighter.

Careful investigation has shown that even in the comparatively pure air of the country districts, remote from furnace and smokestack, there are over a thousand motes of dust in every cubic inch of air. A good, heavy fall of rain washes the atmosphere quite thoroughly, and for a few hours after this purification the air is comparatively free from dust. Falling snow acts in a like manner, and the beautiful white crystals always contain dust particles gathered up in their descent through the air. If the fall be heavy enough, the atmosphere gets a thorough scrubbing. If freshly fallen snow be melted and evaporated, there is always an appreciable quantity of insoluble residual matter. If snow is allowed to remain for a day or two on the roof, the heavy black deposit of soot, so familiar to the dwellers in our large cities, is very much in evidence.

The writer recently gathered a quantity of snow, three days after it had fallen, on the roof of the Fifth Avenue High School, Pittsburg. The snow was melted and the water evaporated. The quantity of snow taken weighed 52 oz. and covered an area of exactly 2 sq. ft. After evaporation, the residue weighed a trifle over 6 grains. A chemical analysis proved this residue to be principally carbon, with a slight trace of iron.

The Peculiar Movement of Dust in the Air. (From an Actual Photograph)

Three grains to the square foot may seem to be rather insignificant; but when we consider the total amount to a square mile, the dust deposit becomes quite impressive, being about 12,000 lb., or six tons. This means that during each of the winter months, at least, this enormous amount of dust falls on the streets and housetops and in the homes in every square mile of the Pittsburg district.

Of such is the Kingdom of Dust!

CHAPTER II

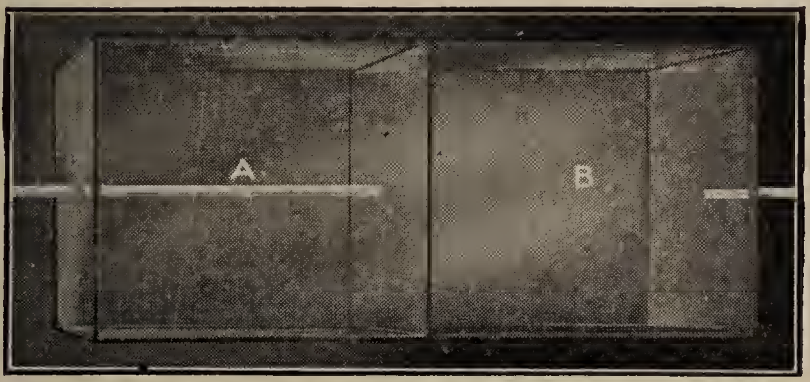
PHYSICAL PHENOMENA PRODUCED BY DUST

The stars at noonday. Invisibility of light. Without optic nerves there would be no light—simply vibrations. The velocity of light. The length of light waves producing red light. Newton's seven primary colors. The cause of sky colors. Professor Tyndall's demonstration of the cause of the azure sky. Professor See's determination of the height of the atmosphere. The application of electricity to the problem of dispersing fog. Professor Lodge's experiments in the University of Birmingham. A Bureau of Mists and Fogs. Importance of the fog dispeller to commerce. Explosions in factories and mines due to dust. Dust as a disseminator of seeds. Dust as a fertilizer. Amount of phosphorus per acre in average farm soil.

HOW strange it would seem were one to look up at the sky at noonday, and, with the exception of the sun's disk, see what one sees at midnight; to recognize planets and constellations glittering afar in the blackness of night, and the disk of the sun, sharply defined, shining with an infinite whiteness against the background of impenetrable darkness!

Yet that is the condition that would prevail were dust eliminated from the scheme of the universe. Gone forever would be the beautiful azures of the day sky; and at eventide and dawn, all the wondrous combinations of ruby and gold, rich lavenders and delicate pinks, that attend as heralds the setting and rising of the sun, would exist only in the memories of those beings fortunate enough to have lived at one time in the Kingdom of Dust.

Through a dustless atmosphere the sun, even at midday, would be visible only when looked at directly. The rest of the sky would be black. We would not have



A Ray of Light Passing Through Two Compartments, from One of Which All the Dust Has Been Removed. The Ray of Light Is Visible Only in the Compartment of Dust-Laden Air

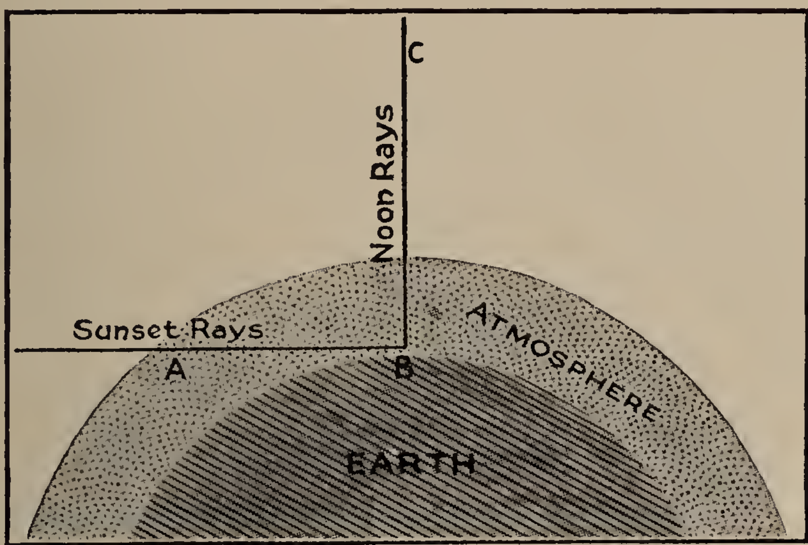
the soft diffused light which bathes land and sea in its pure, mellow flood, and which constitutes what is ordinarily known as daylight.

The explanation is not difficult to understand. The radiations that emanate from the sun are simply quiverings and pulsations of a mysterious, infinitely rare substance known as the luminiferous ether. The shortest of these "light" radiations, when they enter our eyes, produce the effect of violet light upon our consciousness. The longest quiverings or waves cause us to perceive red light.

The waves that produce these results are neither violet nor red. Color exists only in the mind. The same thing is true about sound waves. A bell does not give forth anything other than quiverings, called sound waves. These waves are interpreted by the brain as sound. Were there no eyes nor ears there would be no light and no sound. Were there no operator who understood and could interpret the clickings of the Morse alphabet, there would be no message—only a series of impulses. The trained Egyptologist reads history where the unskilled layman sees only a strange jumble of odd-looking hieroglyphics. In other words, sound waves have no sound, heat waves are not hot, and light waves are invisible, as we understand these different phenomena. They simply affect us so that we feel these different sensations.

To the ordinary observer who sees a beam of light athwart a darkened room from a hole in the shutter on a sunny day, it would seem that light is really visible. The fact is, however, that it is dust motes that render the light visible. These tiny particles of matter intercept the radiant energy known as light and reflect it directly to the eye. An experiment which proves the truth of this statement is shown in one of the illustrations. A box divided into two compartments by a glass partition, and having glass windows at both sides and ends, allows a beam of sunlight to pass through its entire length. One of the compartments, A, contains dust-laden air. The other compartment, B, has its sides smeared with glycerine, which soon catches and retains most of the dust motes. The beam passing through A is visible. The same beam continuing through B is practically invisible, but becomes visible again after passing through the window out into the dusty air. On a moonlight night only the illuminated part of the surface of the moon is visible. The rays from the sun, by which this illumination is produced, are invisible.

Light waves, as we shall continue to call them, travel

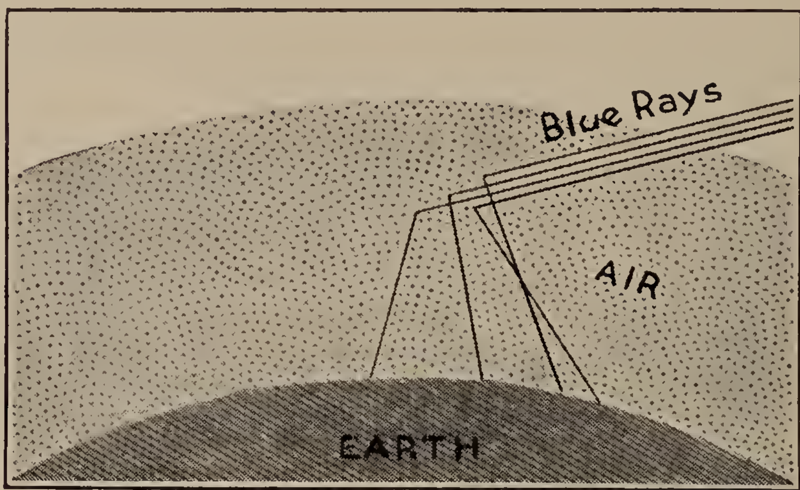


Red and Yellow Rays Are Reflected at Sunrise and Sunset Because at Those Times These Light Waves Travel Through Enough Dust to Reflect Them—Line A-B Is Longer Than B-C

at the rate of 186,000 miles per second, the ether being the transmitting medium. Although these waves travel so rapidly, they are exceedingly small so far as wave length is concerned. Those producing dark red, for example, have a wave-length of only 1/33,000 of an inch, while the violet-producing waves are only about one-half this length.

Light is made up of billions of wave lengths, each of which is responsible for a different color. While Newton thought that there were only seven colors,—violet, indigo, blue, green, yellow, orange and red,—in reality there are as many colors as there are wave lengths—billions.

The fraternity of light waves, undulating through the practically empty ether, travels without let or hindrance

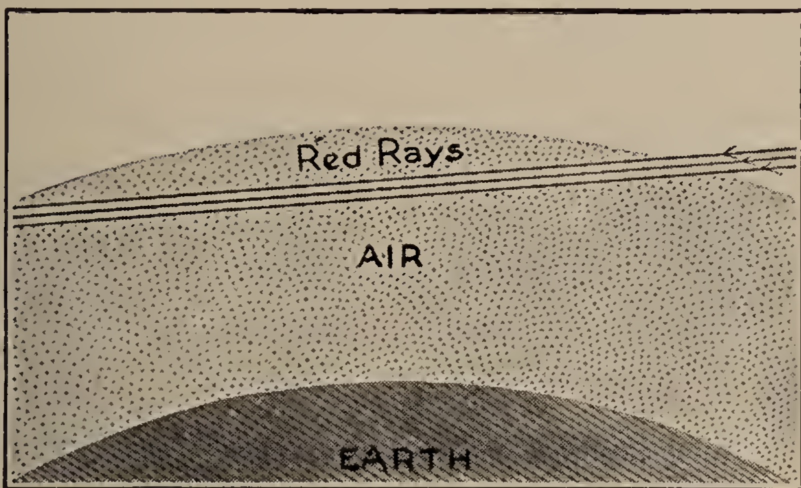


Waves Which Produce Blue Rays Are Interrupted by Dust Motes, Reflecting Them in All Directions. This Causes the Blue Color of the Sky

with equal velocity for all lengths of waves, until the earth's atmosphere is reached. Then the tiny dust particles begin their work of breaking up the brotherhood and sifting out the short waves from the longer ones. Those that produce the reds and yellows are strong enough to brush aside the motes, and go on their way through the air. To the shorter and feebler quiverings that cause the sensations of violet and blue, these small dust particles are insuperable barriers, causing these latter waves to be reflected in all directions. Some of these violet and blue-producing vibrations enter the eye.

As we see an object in the light that comes from it, these innumerable decillions of motes give us the effect of a blue sky.

At sunrise and sunset the reds and yellows are also reflected, as they must pass through a relatively large



Light Waves Producing Red and Yellow Rays Are Strong Enough to Pierce Dust and Continue on Their Way

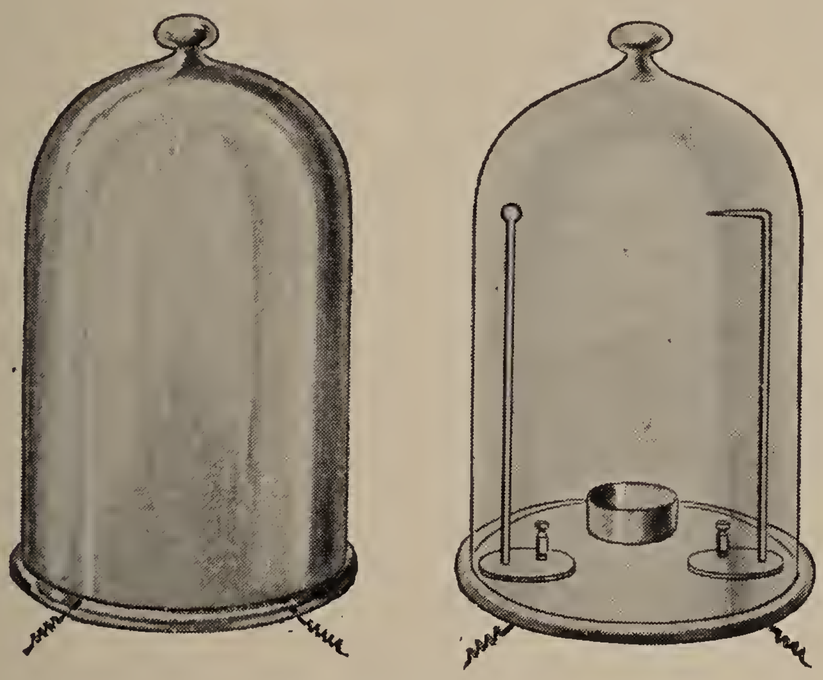
quantity of air, which, on acount of most of it being so much nearer to the earth's surface, contains the larger and heavier particles of dust. This dust is capable of stopping and reflecting the outward flight of these stronger waves. Hence the preponderance of reds and yellows in the evening and morning skies.

In 1869, Tyndall demonstrated in his laboratory the cause of the blueness of the sky. He filled a glass tube about a yard long with air at one-tenth the ordinary density, mixed with the vapor of a substance known as nitrite of butyl, which is quite volatile. On passing a beam of light from a powerful arc lamp through this combination, the mixture appeared as a beautiful blue cloud.

Lord Rayleigh, who investigated Tyndall's experiments in profound mathematical research extending over a long number of years, and who thus satisfied himself that Tyndall's explanation is correct, estimated that the particles that produce the reflection of blue light are less than one-thousandth of an inch in diameter. Some of these particles are motes of dust, others are water, but most of them are composed of particles of oxygen and nitrogen. Professor See, noting that the blue sky continues for about an hour and fifteen minutes after sunset, has made this the basis of a mathematical calculation from which he avers that the height of the atmosphere is fully one hundred and thirty miles.

Dust is responsible, to a large extent, for the formation of fog. Fog is defined as "the aggregation of a vast number of minute globules of water in the air near the earth's surface, usually produced by the cooling of the air below the dew point, whereby a portion of its vapor is condensed."

This is true, of course, but, in order to produce the condensation, there must be small nuclei, or particles of dust, around which as centers the water may condense. In large manufacturing and railroad cities fog is an important factor in industrial life. Many efforts have been made to devise some simple, inexpensive means by which fog may be dispelled. As yet, the use of electrical discharges of high-tension currents seems to be the most practical solution of the problem. Tyndall was the first investigator who sought to disperse this foe of commerce. In 1870 he discovered that heat applied to dust-laden air would free it from particles. This fact may readily be demonstrated by holding a red-hot poker under a beam



Test of the Effect of Electrical Discharge on Fog. First Jar Filled with Artificial Fog. Second Jar Shows Clarifying Effect of Electrical Discharge.

of sunlight filled with glancing dust motes. Immediately, as though by magic, a space is cleared of the dust. Some scientists explain this phenomenon on the theory that the dust particles are really water, and hence dissipated into invisible vapor by the heat. This would not account, however, for the disappearance of the motes which were not water, nor could it be accounted for by convection currents of hot air, as Lord Rayleigh in 1880 showed that a lump of ice held under the dust beam would produce exactly the same effects as the hot poker.

There is no doubt that a molecular bombardment of the dust particles is caused in some manner or other, but no one knew the precise nature of the bombardment until, in 1883, Professors Lodge and Clarke determined to try the effect of an electrical discharge. A bell jar was fitted with wire rods between the terminals of which an electrical brush discharge could be produced. The jar was filled with an artificial fog made from all kinds of substances, such as tobacco, paper, ammonium chloride and lead fumes. The discharge was permitted to take place between the points, and almost immediately the bell jar became free of fog. A practical test of this method of dispelling fog was made by Lodge a few years ago on a fairly large scale in the quadrangle of the University of Liverpool. On a foggy day, when the fog was so dense that one could not see a foot into it, the trial was made. The wire network of the apparatus was connected up to a source of high-tension electrical current. Instantly the fog was dispelled for a considerable space in the vicinity of the wire, thus demonstrating the practicability of Lodge's method of fog dispersion.

The time will come when such fog-dispellers will be put into operation in places where their economic value is highest, such as the entrance to New York harbor, along the Chicago River, the Thames, and other places where their use is clearly indicated. Possibly in the far-distant future all of our large cities may have their Bureaus of Mists and Fogs, dispersing at will the

How New York Harbor Would Look During a Fog, if Electrical Fog Dispellers Were Used to Clear a Channel for Steamships.

occasional fog and the perennial smoke which now envelop us.

Dust is frequently the cause of explosions, as the terrible accidents in coal mines have so often admonished us. The small particles of dust thrown into the air by the blow of the miner's pick, wander up and down through the various rooms and entries and shafts, and become under certain conditions as dry as powder, and likewise as explosive as gunpowder. How many thousands of lives have been lost in this way the statistics of mine casualties of this country and elsewhere will plainly show. Government experts are studying this serious problem with the greatest care, and they have already proposed plans which are apparently giving relief.

Accurate statistics compiled by the United States Geological Survey show that in the sixteen years from 1890 to 1906, 22,840 men were killed in the coal mines of the United States. It has been estimated that at least 11 per cent of these fatalities were due to explosions caused by dust or gas. Many so-called gas explosions are really due to dust, as recent research has revealed.

Dust explosions occur quite frequently in flour mills and in factories where fine dust is generated. The greatest care must be taken to prevent even the smallest spark of fire in the room where the dust is flying.

In at least one respect dust is a public benefactor. It is an exceedingly important agent in the transfer of vegetable organisms, seeds and spores to the waste and barren places of the earth. "Perhaps," says M. Barral, a distinguished French scientist, "it would be correct to say that the air remaining in a condition of purity equal to that which is sometimes obtained in our laboratories would strike the earth with barrenness. Perhaps, too, it is necessary for the maintenance of life on our planet that a host of impurities should be incessantly carried hither and thither by the winds and storms, from the places where they are produced to regions where germs are waiting to be fructified."

Dust is undoubtedly a fertilizer. Particles of phosphoric matter are often detected in the atmosphere, transported from regions where phosphate of lime is abundant. As each crop of grain draws on an average of 17½ lb. of phosphorus per acre from the soil, we may readily perceive the importance of a new supply of this invaluable element.

We can understand also why it is that races like the Arabs, who never attempt to fertilize their lands, are necessarily nomads. They live in one place long enough to exhaust the soil, using up the chemical elements essential to the production of grain and other foodstuffs, and then move on to pastures new, allowing the soil, through dust and other natural agencies, to recover itself for future tillage.

CHAPTER III

COSMIC DUST

Projectiles from beyond the earth and solar system. Proof from the deep sea. Iron from mountain snows. "Shooting stars," number falling every twenty-four hours. Time required to deposit an inch of dust. Lengthening of day and shortening of year through cosmic dust. Widmanstätten and his curious discovery. Meteorites furnish no evidence of life in other planets. Extremes of heat to which meteorites are subjected. Nebulæ. The nebular and other cosmic hypotheses. Arrhenius' estimate of dust particles necessary to obscure the light from the stars. The nature and composition of comets. The danger of collision with a comet.

FEW of the inhabitants of this old world of ours realize that we are constantly being bombarded from the heavens above and below us. Every twenty-four hours from ten million to fifteen million shots are fired, each of the projectiles having a velocity far greater than that of a rifle bullet; and this does not include the myriads of projectiles too small to be seen by the naked eye. Luckily for us, we are protected by a sheathing of atmosphere that is quite effective against these swiftly moving messengers from outer space. Occasionally a mass weighing anywhere from a pound up to a ton or more slips through, but, for the most part these projectiles are tiny particles of dust and gas, and their only effect is to produce a brilliant streak of light known to us as a "shooting star." A "shooting star" is in no sense a star. Were a real star to strike our earth, this planet would vaporize almost instantaneously, and all that would be left of us would be an incandescent mass of gas and vapor, just as we once were, billions of years ago.

When a "shooting star" strikes our atmosphere, its energy of motion is transformed into heat, from the friction produced by the air, and the "star" is literally burnt to ashes. These ashes fall upon us in a continual shower, and constitute the greater part of what is commonly known as cosmic dust. Nordenskjöld, the Swedish naturalist, by melting several tons of snow in far-off Spitzbergen, found distinct globules of iron in the sediment thus obtained. By the use of a specially constructed dredge, ooze from the bottom of the deepest part of the ocean has been brought up, and part of it is undoubtedly cosmic dust.

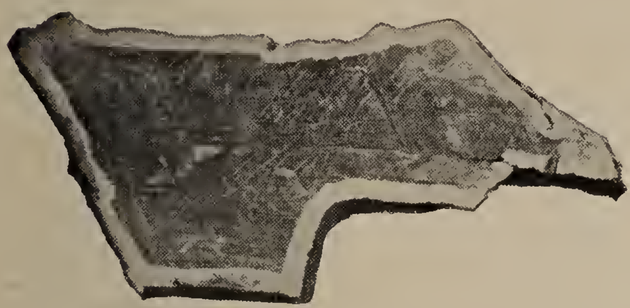
It is extremely difficult to determine the chemical composition of these cosmic visitors, but in a few instances observers have been fortunate enough to analyze the light of "shooting stars" by means of the spectroscope, and have determined the probable presence of sodium and magnesium. Although the earth is continually receiving additions to its mass in the form of finely divided dust, it would take a long time to gather enough to make any appreciable difference in its weight or its velocity. It has been calculated that it would take at least a thousand million years to accumulate enough dust of this character to make a layer an inch thick all over the surface of the earth. And yet, insignificant as is this small daily accretion of cosmic matter from meteors and "shooting stars," it is bound, in time, to bring about important and wonderful changes in this old globe of ours. For example, this added weight will gradually shorten the year by adding to the mass of the earth, thus increasing the attraction between the earth and the sun; it will diminish the size of the orbit of the earth, adding to its velocity, and it will increase the length of the day by increasing the earth's diameter.

However, it is quite unnecessary for us to worry about any possible changes in the calendar, or to take into account the increased length of day, as from all these sources it will take over a million years to make a change of one second in the length of our year.

The meteors which flash through the air and fall upon the earth as meteorites are objects of wonderful interest. How delightfully vague is their origin! What untold billions of miles have they traveled! What wonderful tales could they tell were they able to talk to us about their age-long wanderings! Possibly they were thrown out from our own sun, as no elements have been found in them which are not present in the chief of our solar system. At one time it was suggested that possibly these strange wanderers from out the infinite realms might be messengers projected to us from the inhabitants of other worlds than ours.

A German scientist, Widmanstätten, made a curious discovery, which at first glance seemed to bear out the dream of those who believed that possibly some meteorites might be messengers from sentient beings somewhere in the vast empyrean. When meteoric irons are etched by a powerful acid, strange figures and designs appear upon the surface. Immediately, the fanciful seized upon these Widmanstätten figures as absolute evidence of an effort on the part of the inhabitants of other worlds to communicate with us.

In 1880, an attempt was made by Dr. Hahn, of



The Widmanstätten Figures as They Appear on a Section of Meteoric Iron

Meteorite Which Fell at Canon Diablo, Colo.

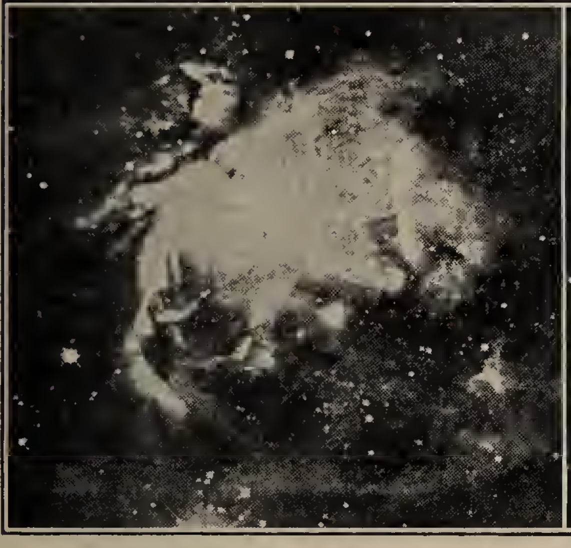
Tübingen, to prove the presence of animal life such as crinoids and corals in a certain meteorite, and he also claimed that the Widmanstätten figures are the result of plant life. Scientists generally regard this memoir of Hahn's as an elaborate jest. Widmanstätten's figures, as shown in one of the illustrations, are probably due to crystallization resulting from the intense heat to which the meteorite was subjected in its passage through the atmosphere. In other words, the meteorites, siderolites and aerolites that have come to us from afar have not furnished us with a scintilla of evidence of life beyond our earth.

It is true that some of the visitors from outer space show the presence of carbon to a marked degree. While carbon is a strong presumptive evidence of life, since it is by plants that carbon is elaborated from gaseous compounds, it has been pointed out that the carbon in meteorites may have been derived from the atmosphere by absorption. Professor Maskelyne has shown in this connection that all carbon compounds in a meteorite may be completely removed without pulverization of the stone, thus bearing out the theory that the carbon is only in the pores of the meteorite, and not an original constituent.

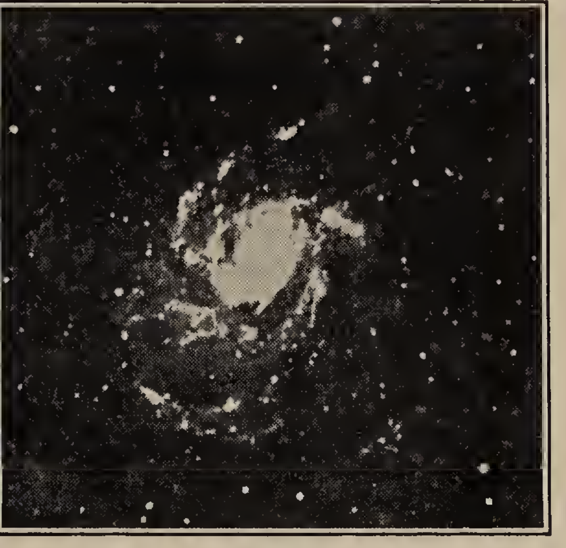
A curious fact concerning the extremes of temperatures to which meteorites have been subjected is worth noting. A meteorite moving through space beyond the atmosphere receives heat only from the sun and stars, and as the temperature of space is very low, probably near to the absolute zero of temperature, 459° below Fahrenheit zero, these wanderers in space are extremely cold. And yet when they fall upon the earth their outer crust of iron is curiously pitted from the intense heat produced by the friction of the atmosphere. These pittings are undoubtedly due to partial melting. As iron melts at 2000° Fahrenheit, a meteorite passes in a short interval through a range of nearly 2500° Fahrenheit.

The interior of a large meteorite is intensely cold for a considerable time after its fall. One which fell in India, in 1860, embedded itself in moist earth, and was found, half an hour after its fall, coated with solid ice. After a meteor has passed through the atmosphere, very often a train of luminous dust is left which glows sometimes for an hour. Physicists have speculated as to the cause of this luminescence, as it could not possibly be from heat. A similar phenomenon has been observed when certain substances are cooled below the temperature of liquid air. Whatever may be the cause, it is certainly a case of light without heat.

On a clear starlit night, anyone possessed of good eyesight may see a faint haze-like cloud of glowing

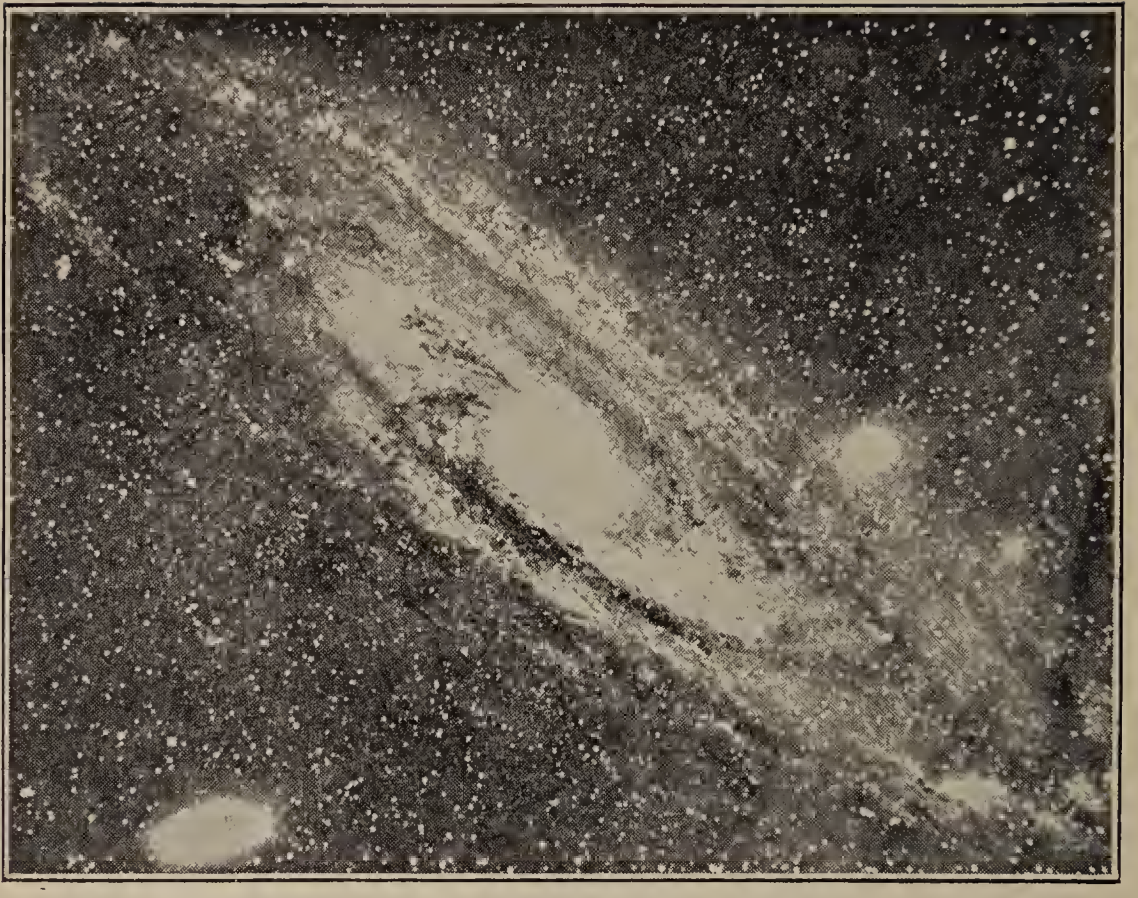


The Great Nebula in "Orion"



Spiral Nebula in the "Great Bear"

splendor in the girdle of the constellation Andromeda. If Orion is above the horizon, the same phenomenon may be observed in this well-known group of stars. These shining cloudlike forms, far-flung throughout the starry depths, a billion times more delicate than the filmiest lace ever wrought by the hand of woman, are known as nebulæ. It was formerly thought that they were stars so remote that no telescope could ever resolve them. It is now known that they are not stars, but are probably made up of extremely rarefied hydrogen, and other gases, containing small particles of solid matter—

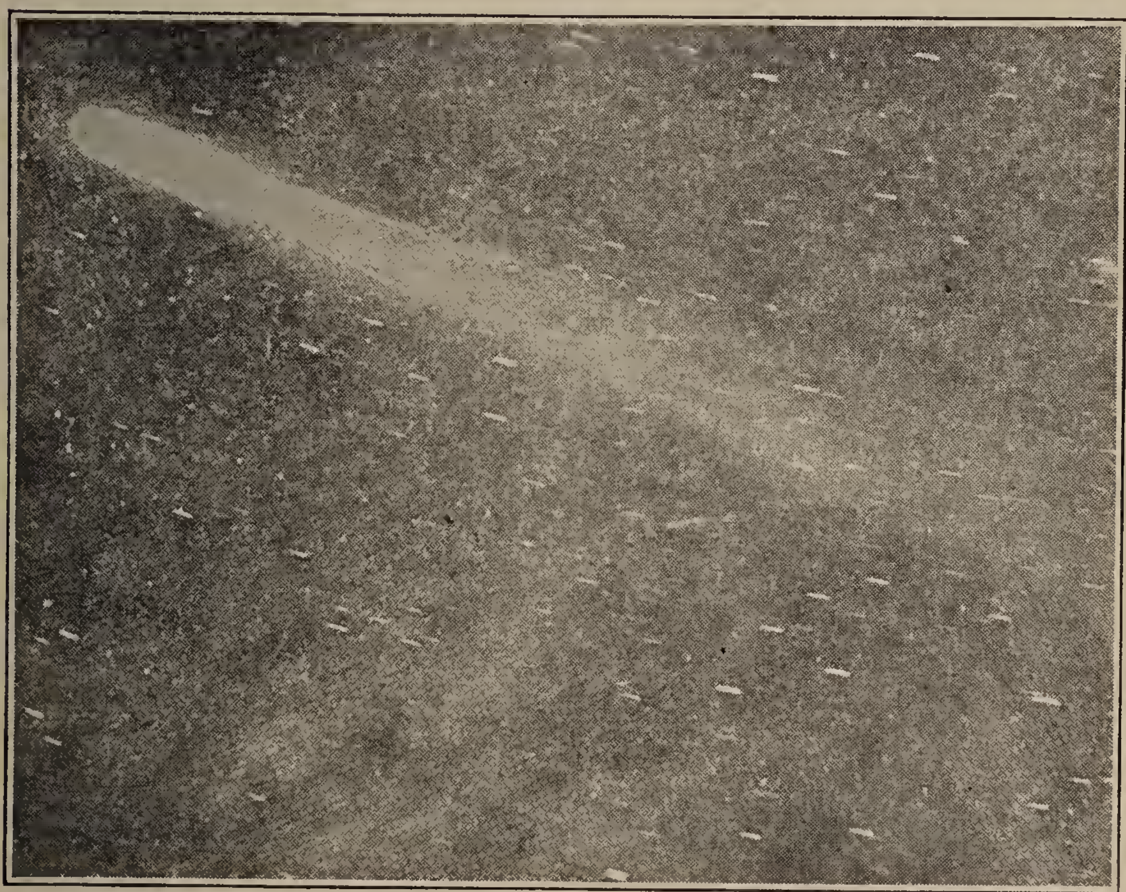


The Great Nebula in "Andromeda"

outposts of the Kingdom of Dust. These nebulæ are of different forms: some are lens-shape, others resemble a dumb-bell, while many occupy billions of miles in the form of great winding spirals.

From a study of these nebulæ, Laplace, Kant and Swedenborg evolved the famous nebular hypothesis, a wonderful and stupendous conception, which seeks to account for the origin of such aggregations as our own solar system. Briefly stated, the nebular hypothesis is simply this: that our sun, for example, was once a nebula extending far beyond the present orbit of the uttermost planet Neptune; that a revolving, whirling motion was set up in this nebula, and that the different planet masses were set free from the parent mass; that these planet masses in their turn disengaged still smaller masses, which formed the various moons of the solar system; that the sun is all that is left of the original mass of our primal nebula.

There are quite a number of objections to the nebular hypothesis, one being the failure to account for the peculiar distribution of the larger and smaller planets. Professors Moulton and Chamberlain have formulated a



Daniel's Comet, 1907

very clever and reasonable modification of the nebular theory, known as the planetesimal hypothesis. This does away with a number of the inconsistencies of the original theory of Laplace, and is quite favorably regarded by scientists.

Another theory is known as the meteoric hypothesis, or "capture" theory, so strongly advocated by Professor See. According to this, the larger masses in the universe attract to themselves the smaller bodies.

Although we know not which theory is nearest to the truth, there can be no doubt that small particles of matter—world dust in fact—form the primordial stuff of the universe, and that in all probability all the heavenly bodies, from the giant suns like Sirius down to the smallest particle of cosmic dust that constitutes a shooting star, originated in dust—dust so fine that stars of small magnitude may readily be seen through it.

It is quite probable that cosmic dust, although it is so fine and so rare, has an important effect, in fact, that it obscures to a greater or less extent the light of the more distant stars. We see through a veil of dust, and it is quite likely that the stars whose distance has not been determined are not nearly so far away as they appear.

Arrhenius has estimated that if there are upward of a hundred particles of cosmic dust to every cubic mile of space, evenly distributed, they would be sufficient to block from our view the most distant stars, and to render much fainter the light of those that are nearer.

Closely allied to meteorites and nebulæ are those wonderful and spectacular members of the celestial family known as comets. Sweeping through the heavens with frightful velocity, and occupying such vast areas with their shining tails, it is no wonder that they have been objects of superstitious dread in all ages and climes. There are known to us about 450 of these mysterious cosmic tramps, and all are members of the solar system. Between thirty-five and forty of these are termed periodic comets, as their orbits have been calculated and their return may be prophesied with certainty. The others are the waifs and strays of our solar system, and some of them have immensely long periods. The comet of 1811, for example, will not make us a return visit until the year of our Lord 4876.

What is a comet? Simply a mass of shining dust and gas, with possibly some larger particles of matter as a nucleus or head. As regards a comet's weight, no one has been able to estimate it, for the reason that no comet has as yet been observed to have the slightest pull on any of the planets. Some astronomers claim that an ordinary comet could be crowded into a hat-box, and would weigh only a few pounds, while others assert that millions of tons would be nearer the truth. The constituent matter of a comet is distributed over such a tremendous area that its average density is less than the vacuum of an incandescent electric bulb. That a comet is made up of highly rarefied matter is shown by the fact that stars, whose light we could not see through fifteen miles of ordinary air at sea level, may readily be seen through ten million miles of a comet's tail.

It is quite probable that at certain times our own earth has a cometary tail, extending five or six hundred miles into space. The wonderful Aurora Borealis and the Aurora Australis are supposed to be electrically illuminated particles of gas and dust similar to those observed in the tails of great comets. The earth's comparatively enormous mass prevents the escape of any noticeable portion of our gaseous envelope, and hence we are unable to rival the smaller bodies in the length of their appendages.

CHAPTER IV

EARTH'S WINDING-SHEET

Man's proudest monuments. Buried cities of the past. The absolutism of decay. The doom of the Himalayas. Rate of erosion of the North American continent. Mean height of North America. The work of the Mississippi River. Volcanoes as dust-makers and distributors. St. Pierre and its volcanic outburst. The trail of Krakatoan dust around the world caused the brilliant sunsets of 1883-1886. *Pliny's dramatic story of the destruction of Pompeii. Captain Hall's account of the St. Vincent eruption. Analysis of volcanic dust. Dust storms. Loess. Sand dunes. The Desert of Sahara. The fate of Northern Africa. The shifting of the sands.*

Ah, make the most of what we yet may spend
Before we, too, into the dust descend.
Dust into dust, and under dust to lie,
Sans wine, sans song, sans singer, and sans end.

For I remember stopping by the way
To watch a potter thumping his wet clay,
And with its all-obliterated tongue
It murmured, "Gently, brother, gently, pray."

Omar Khayyàm

AS dust was the beginning, so shall it be the end of all things earthly. It is the cosmic sexton of the ages, and silently, resistlessly and eternally it has performed its functions. The proudest monuments built by man—the Sphinx, the Pyramids, the Colossus of Rhodes, the Gardens of Babylon, the glories of Grecian art—have either crumbled to the dust whence they sprang or have been buried deep in its winding-sheet. So far as human grandeur is concerned, even "imperial Caesar, dead and turned to clay, might stop a hole to keep the wind away." No one knows how many Londons or Jerusalems there have been. Excavations in the dust on which these cities are built reveal the remains of former cities, once flourishing and powerful, but which were finally entombed in the course of centuries by gradual but overwhelming deposits of dust and debris. When Macaulay's New Zealander shall muse in profound melancholy upon the shattered remains of London Bridge, he will behold a vast battlefield where half-buried columns and desert sands shall proclaim the final sovereignty of Dust.

How many cities, like Nineveh and Babylon, and the unnumbered cities of the plains, are known to us only by a few shards and fragments of pottery drifting about in deserts of shifting sand?

The mighty Himalayas, whose snowy summits have as yet defied the foot of man, are slowly crumbling into dust, and the lofty peaks of the Andes are splintering, fragment by fragment, until they, too, shall become clods of the valley. Every wind that blows "soft o'er Ceylon's Isle" carries away in tiny dust particles some of its beautiful hills and vales. Every brooklet trickling down the rugged mountain side bears part of a continent to the sea. Every year the Mississippi River carries down

The "Seven Wonders of the World"

to the Gulf little motes of matter, river-worn dust amounting to over 7½ billion cubic feet. In 3,500 years the Mississippi cuts down its entire basin one foot. The mean height of the continent is only 2,000 ft., and therefore, if the process goes on uninterruptedly, North America will be reduced to the sea level in about 7,000,000 years. When we consider what the other great rivers of the globe are doing, such as the Nile, the Yang-tse-kiang, the Yukon, and the Danube, we can appreciate in some measure the everlasting waste that is eating away great continents, and foresee the inevitable supremacy of the Kingdom of Dust.

Volcanoes are active agents in the formation and distribution of dust. On August 27, 1883, a violent explosion took place on the island of Krakatao, in the Sunda Strait. Half of the island was destroyed. According to official evidence, the explosion was heard at a distance of 1,800 miles, and the air wave that accompanied it injured buildings hundreds of miles distant. Immense quantities of dust, some coarse, some fine, were projected into the atmosphere. This dust, the fragments of a volcanic island, was carried into the upper atmosphere, and some of it circled the entire globe twice or thrice before it finally disappeared. The brilliant sunsets, glorious in their chromatic splendor, that characterized the years 1883, 1884, 1885 and 1886 were due to the minute dust particles from this volcano. And even to this day, after almost three decades have elapsed, it is quite probable that dust from Krakatao is still flitting aimlessly in space, silently moving throughout the profound wastes of the aerial sea. Possibly some of the finer dust, attaining the higher reaches of the atmosphere and impelled by the pressure of light, has left the confines of earth forever and has begun an age-long wandering into the awful abysms of interstellar space.

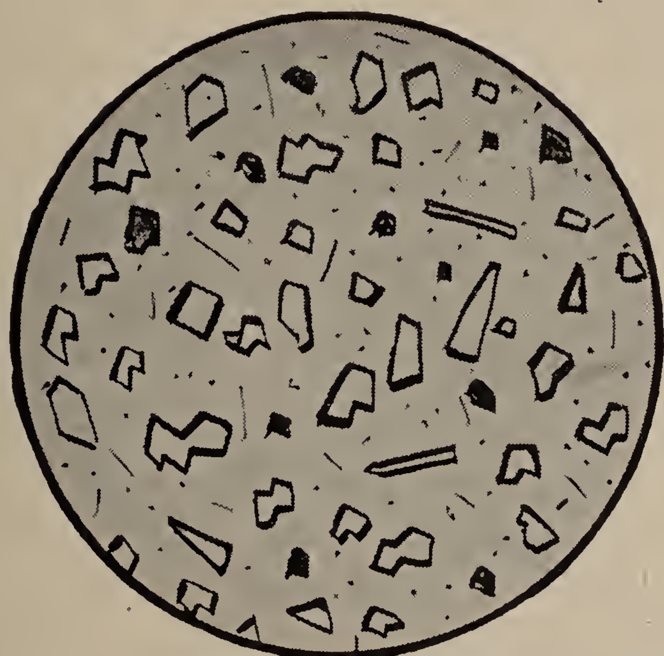
Every Wind Carries Away Dust Particles of the Roman Forum

The volcanic outburst of St. Pierre with its tremendous outpouring of dust, in May, 1902, is still fresh in the minds of many. Professor Jagger, of Harvard University, who visited Martinique the day following the greater outburst, wrote:

"I looked toward the gray old volcano, whose summit was shrouded, but the lower slopes were sunlit, silent and powdery. The whole landscape is powdery, like old statuary with a dust coating, that makes stronger the modeling of the city."

The most dramatic description of a volcanic eruption ever penned by man was written by Pliny the Younger. in a letter to Tacitus. After a preliminary account of the eruption of Vesuvius, he said:

"At length, preceded by a strong sulphurous stench, a black and dreadful cloud, skirted on every side by forked lightning, burst into a train of fire and igneous vapor, descended over the surface of the ocean, and covered the whole bay of the crater, from the island of Capreæ to the promontory of Misenum, with its noxious exhalations; while the thick smoke, accompanied by a slighter shower of ashes, rolled like a torrent among the miserable and affrighted fugitives, who, in the utmost consternation, increased their danger by pressing forward in crowds, without an object, amidst darkness and desolation. Now were heard the shrieks of women, screams of children, clamors of men, all accusing their fate, and imploring death, the deliverance they feared, with outstretched hands to the gods, whom many thought about to be involved, together with themselves, in the last eternal night. Three days and nights were thus endured in all the anguish of suspense and uncertainty. Many were doubtless stifled by the mephitic vapor; others, spent with the toil of forcing their way through deep and almost impassable roads, sank down to rise no more; while those who escaped spread the alarm, with all the circumstances of aggravation and horror which their imaginations, under the influence of fear, suggested. At length a gleam of light appeared, not of day, but fire; which, passing, was succeeded by an intense darkness, with so heavy a shower of ashes that it became necessary to keep the feet in motion to avoid being fixed and buried by the accumulation. On the fourth day the



Dust from the St. Pierre Eruption (Magnified 500 Diameters)

darkness by degrees began to clear away, the real day appeared, the sun shining forth sickly as in an eclipse; but all nature, to the weakened eyes, seemed changed; for towns and fields had disappeared under one expanse of white ashes, or were doubtfully marked, like the more prominent objects after an Alpine fall of snow.

"If such were the terrors of this most tremendous visitation as it affected Stabiæ and Misenum, comparatively distant from the source of the calamity, what must have been the situation of the unfortunate inhabitants of Pompeii, so near, or of Herculaneum, within its focus? Must we not conclude that, at the latter place at least, most of those not overwhelmed by the torrents of stony mud which preceded others of flaming lava, burying their city 60 feet under the new surface, were overtaken by the showers of volcanic matter in the field, or drowned in attempting to escape by sea, their last, but hopeless resource, since it appears to have received them to scarcely less certain destruction?"

The recent disaster at Martinique recalls to mind the eruption of St. Vincent in the year 1812. A sea captain, Basil Hall, wrote a very graphic and striking account of this modern Pompeii, and his own words are best in describing it:

"On the first of May, 1812, after some violent detonations that terrified the inhabitants of the Barbadoes, a black cloud was descried, seaward, upon the northern horizon. Ere long it covered the whole sky, which had just been emerging from the shadows of morning twilight. At length the darkness became such that it was impossible, indoors, to tell where the windows were, while, in the open air, many persons could not see the trees near which they were passing, the outlines of the neighboring houses, or even white handkerchiefs placed a few inches from their eyes. This phenomenon was occasioned by the fall of an enormous quantity of volcanic dust issuing from a crater on the Isle of St. Vincent, and containing, according to the analysis made by Dr. Thompson, 91 parts of silex and aluminum, 8 parts of calcareous matter, and 1 part of oxide of iron. This new kind of rain and the profound darkness it occasioned did not cease entirely until between noon and one o'clock; but several times during the morning there were noticed, by the aid of a lantern, showers, so to speak, in which the dust fell in greater abundance. Trees whose wood was flexible bent beneath the burden, and the noise that other trees made in breaking contrasted in a very striking manner with the calmness of the atmosphere. The sugar canes were completely broken down, and the whole island was covered with a bed of greenish ashes an inch in depth."

In many parts of the world there are dust storms so dense and so frequent that travelers when caught in them are in imminent danger of their lives. These storms are known under various names, such as the harmattan, the khamsin, the sirocco and the simoon. They transport from place to place immense quantities of dust.

That these great dust storms have always been in evidence since the world began is shown by certain geological formations. Along the valleys of the Rhine and the Mississippi, in Central China, North Germany, Poland, and in the Carpathians, are immense deposits of a peculiar dust known as "loess," a fine powder produced by the grinding of prehistoric glaciers and consequent flood streams. This loess is generally of a brownish or yellowish color, and sometimes has a depth of over 2,000 ft. Pumpelly, in describing the loess of China, says:

"In Asia, thousands of villages are excavated in the most systematic manner at the base of cliffs of loess. Doors and windows pierced through the natural front give light and air to suites of rooms which are separated by natural walls and plastered with cement made from the loess concretions. These are the comfortable dwellings of many millions of Chinese farmers and correspond to the rude 'dugouts' of Nebraska."

Loess is never stratified, and hence was not water-deposited. It is simply dust that has overwhelmed cities and villages and even mountains with a fine powdery deposit. In Central Asia the air is sometimes so thick with sand and dust that it is impossible, on these occasions, to read a book at noonday. Along the Caspian steppes, fine clay and sand are constantly drifting, and no plant life can exist where these storms are common. Even in our own country, especially along the seashores, we have many examples of the wastes produced by sand dunes. These dunes, like those on Cape Charles, overwhelm and destroy every living in their pathway.

The terrible desolation produced by shifting sands, however, may best be seen in Northern Africa. The desert of Sahara is a typical example. Wind-driven, the white, powdery sand sifts ceaselessly over the ancient domain of the Pharaohs. Almost all of Northern Africa is now naught but a desert, and in a few hundred years, the sand will have reached the mountains near the Red Sea; inevitably it will overtop these natural barriers, and march onward into Arabia, carrying ruin and destruction in its train.

Mysterious, dreamy Egypt, whence has come so much that has made the world wiser, is being slowly entombed by the relentless shifting sands. The grim and silent Sphinx, wistfully looking afar with its dust-bleared eyes, beholds only wastes of shining sands where once fair

Sand Dune Overwhelming a Forest at Cape Charles, Va.

rising uplands, graced with beautiful temples and stately façades, marked the garden-spot of the world. Even the Sphinx itself is slowly sinking into the dust with its riddle unanswered, its mystery unrevealed.

Perhaps in some future age the sands will roll away, Earth's winding-sheet will unfold, and again will the

Sphinx, the strangest of all the handiwork of man, ask in vain, with lips of stone, its world-old riddle, before it disappears, for all eternity, into the wonderful Kingdom of Dust.

CHAPTER V

THE FOE OF THE WORKMAN

The inhalation of dust particles. Inability of the phagocytes or microbe-eaters to cope with dust. Black lines of dust in the lungs, marking the trail of death. Table showing the amount of dust inhaled daily by the artisans of various trades. "Steel grinder's consumption," "Stone-mason's phthisis," "Potter's rot." High percentage of iron dust in the subways of New York City. Table showing the toll paid to dust by workmen in the various arts. Plumbism, or lead poisoning. Women peculiarly liable to all the forms of lead poison. How copper and mercury affect the workman. The boon given to mankind by the discovery of red phosphorus, and its use in the manufacture of matches. Arsenic in wall paper. Arsenic in furs.

SCIENCE with her wizard appliances has done marvelous things for mankind in the matter of protection against disease. She has searched out the causes of the scourges that formerly played havoc with the human race. Smallpox, diphtheria, cholera and typhoid fever have been hunted down and made to reveal their death-dealing secrets. We have learned to be cautious as regards the character of our drinking-water. We know the danger of the malaria-carrying mosquito. We appreciate the insidious menace of the common housefly. We understand the importance of enforcing pure-food laws. Nevertheless, there is one avenue, long and wide, along which disease and death march arm in arm, right into the very heart of the citadel of life. It is the highway that leads from the Kingdom of Dust. The myriads of dust motes are the real executioners of mankind, especially in those occupations where the formation of dust is a necessary concomitant.

An average man breathes about 21 cu. ft. of air per hour. Under the very best conditions possible, the air he breathes is never entirely free from dust. Under ordinary conditions, the average business man in his comparatively sanitary office breathes in thousands of dust particles every hour. The workman who earns his livelihood in shop, factory, or mine has his proportion of motes enormously increased, owing to the nature of his work; unfortunately, also, the character of these particles is too often changed from the innocuous kind to the death-dealing splinters due to certain occupations.

An artisan working with keen-edged tools must exercise extreme care in order to prevent harm to himself. If he is surrounded by circular saws revolving at lightning speed, or with vats of corrosive acids, or furnaces of molten steel, these perils are at least in open view, and may be guarded against. It is different, however, with the dangers lurking in dust. They are invisible, although none the less deadly. In a steel-grinding factory the air is charged with flying, jagged splinters of steel infinitely sharper and more dangerous than the razor-edged tools to which the worker is accustomed. Every breath sends bits of metal, keener than Damascene blades, right into the midst of his delicate lung tissue.

The Potter The Cigarmaker The Painter Poison in Furs

Death in the Dust

It has been said that every human being in the course of an average life must eat a peck of dirt. But what about the dust we breathe? The peck of dirt is comparatively harmless; the dust is either an irritant, producing inflammation, or else it may be a toxic substance, eventually causing death. The lungs of a gold miner, for example, upon chemical analysis, showed 24.4 per cent of their total weight to be pure silica, inhaled during the work of rock-drilling.

It is true, of course, that the "phagocytes" or microbe-eaters in the lungs, act as scavengers and tend to keep the tissues free from organic dust; but they are practically powerless in the matter of inorganic material such as sand and clay. All that the phagocytes can do with such materials is to transport them to the bronchial glands. After death from "dust consumption" long black lines of pigment may be observed, marking the course of the dust particles through the respiratory apparatus. Hesse, a German scientist, has made a careful study of the amount of dust inhaled by workmen in different trades, as is shown by the appended table:

	Per day	300 days per year
Iron foundry	2.16 gr.	648 gr.
Tobacco works	5.6 gr.	1680 gr.
Flour mill	1.93 gr.	579 gr.
Chemical works	17.3 gr.	5190 gr.
Saw mill	13.9 gr.	4170 gr.
Horsehair works	7.7 gr.	2310 gr.

From this it follows that an ironworker adds over an ounce of iron dust to his lung tissue every year! Of course, all of this dust does not remain permanently in the lungs, but some of it does, especially the jagged splinters of steel, which imbed themselves deeply in the tissue. Is it any wonder that fibroid phthisis results? Is it any wonder that we hear so frequently of "steel-grinder's consumption," of "stonemason's phthisis," and of "potter's rot"?

Not only are the immediate workers in the shops affected by this dust of death, but the ordinary wayfarer on the streets and highways must take his proportion also of this concentrated essence of disease. For example, a careful investigation of the conditions prevailing in the 21 miles of subway in New York City indicates that in each 1,000 cu. ft. of air there are 61.6 milligrams (0.00217 oz.) of dust, and that 61.3 per cent of this dust is pure steel in jagged splinters! This high percentage of metal is accounted for by the fact that the brake-shoes alone wear down at the rate of 2,000 lb. per month, without taking into account the loss from the wheels and rails.

Microphotographs of Normal and Dust-Filled Human Lungs and of Dust from Some of the Hazardous Trades.

The list of trades that pay tribute to the Kingdom of Dust is very large, and few people realize the startling proportions of the part played by dust, or the tremendous havoc wrought by this frightful, insidious agent of death. The following table, compiled from Sommerfield, will give some notion of the tremendous toll dust takes from mortals:

	Deaths due to phthisis per 1,000 persons	Deaths due to phthisis per 1,000 deaths
Occupation without production of dust......	2.39	381
Occupation with production of dust..........	5.42	480
Population of Berlin of same age............	4.93	332.3
Trades giving rise to—		
A. Metallic dusts	5.84	470.6
(a) Copper trades	5.31	520.5
(b) Iron trades	5.31	520.5
(c) Lead trades	7.79	501.7
Trades giving rise to—		
B. Mineral dusts	4.42	403.4
(a) Pottery workers	14.00	591.0
(b) Stonemasons	4.26	382.0
Trades giving rise to—		
C. Organic dusts	5.64	537.04
(a) Dust from leather, skins, feathers	4.45	565.9
(b) Dust from wool and cotton......	5.35	554.1
(c) Dust from wood and paper.......	5.96	507.5
(d) Dust from tobacco..............	8.47	598.4

It will be observed from a study of this table that dust, on the average, adds 25 per cent to the death rate! In some cases, as in the trades of pottery-making and tobacco-handling, this percentage is cruelly increased, being 55 and 57 per cent, respectively!

The painter, who deftly adorns and protects the woodwork of our homes with a thin covering of paint derived from lead, is working with one of the most dangerous poisons known in the arts. "Painter's colic" is produced by lead dust. And not only do painters suffer from lead-poisoning, but likewise a host of other artisans in a variety of trades are afflicted with "plumbism" in one or other of its many forms. The potter secures the beautiful glaze on his handiwork by means of lead. The enameler, who covers iron plates with the deep blues, rich vermilions, and snowy whites so familiar to us in the letters cemented on the glass of shop windows, has much to do with lead, and suffers accordingly. Even the diamond-cutter has more to fear from the dust of the lead and tin "knob" in which the diamond is imbedded than from the diamond dust itself. The printer who handles lead type, the file-cutter who uses lead in a certain stage of his work, the glassworker, the electrician who builds electrical accumulators, the shipbuilder, the lithographer, the dyer, and a score of other artisans, all suffer from the insidious poison in the dust from lead. For some curious reason, women are especially liable to lead-poisoning, and many attempts have been made to secure legislation that would prevent the employment of women in the manufacture of white enameled beds, in which lead is used so abundantly.

Before leaving the subject of lead dust, it may be well to reiterate the oft repeated warnings against drinking water that has stood for any considerable time in lead pipes. Water is a powerful solvent. It will dissolve practically every substance under the sun, and gradually takes up, little by little, enough lead to render the water slightly poisonous. Lead is a "cumulative" poison, and, particle by particle, it collects in the body, producing in time the well-known effects of lead-poisoning. No doubt many thousands of people in every large community suffer from plumbism in a mild form. They may not suffer from "wrist drop" or develop the characteristic blue line on the gums, but they do develop minor symptoms sufficient to make life miserable, and yet not pronounced enough to alarm the sufferer or to cause him to seek the aid of a physician.

All workers who handle copper and brass absorb minute portions of these metals that wear off from the surface of rods and implements, and poison their hands. Every street-car passenger has observed the peculiar greenish appearance of the hands of the motormen and conductors who are constantly in touch with either the brass rods on the summer cars, or of the brass handles of the controllers. A "green" motorman or conductor learns to his sorrow that brass must be handled, literally, with gloves.

Mercury in the form of dust, claims thousands of victims annually. In the extraction of gold from the ore, mercury is, in several processes, quite essential, and the operators suffer from mercury-poisoning. Workmen in factories where thermometers are made have constantly to be on their guard against the entrance of mercury dust into the mucous membrane of the body.

Phosphorus is another substance from which fatal effects are produced by the entrance of a small amount of "dust" into the body. The recent dedication to the public of the patent rights of a harmless process for the manufacture of matches from phosphorus will save thousands of lives.

The gilding on Christmas cards is obtained by a process known as dry bronzing, in which the deep reds and greens, as well as the silver and gold, are produced by a mixture of copper, zinc and arsenic. The dust, when breathed, sets up an inflammation of the respiratory tract which afterward becomes chronic.

Arsenic was formerly much used as a coloring-matter in wallpapers. The wonderful greens, yellows, browns and reds of a score of years ago had for their base an arsenical compound. Many weird tales are told of "haunted" chambers where death was sure to overtake the unfortunate traveler who slept a stated number of nights in a certain bedroom. Investigation has shown that the walls of such apartments were frescoed with arsenical colors. These pigments constantly give off a very fine dust. This dust, breathed into the lungs for a period of eight or ten hours, causes all the preliminary symptoms of arsenical poisoning, and if inhaled night after night would eventually cause death. Fortunately for the public weal, the use of arsenic as a coloring for wallpapers has practically ceased.

Workmen who are employed in the manufacture of the arsenical compound known as Scheele's green suffer from painful ulcers. The use of arsenic in the curing and preservation of furs is also a source of danger, not only to the workman who prepares the fur, but likewise to the unsuspecting wearer of the garment. Arsenic is a powerful insecticide; hence its use as a preservative. About 25 per cent of the furs recently examined by an American chemist proved to be heavily laden with arsenic. The use of more than one grain of arsenic per square yard is forbidden by law, and yet 170 grains have been found in that area.

In the damp, hot atmosphere of churches and theaters in winter, the danger from arsenical poisoning rises to the maximum, although few people suffering therefrom are willing to attribute it to their handsome furs.

CHAPTER VI

THE SKELETON IN THE CLOSET

A strange botanical excursion. The tangled forest in a jelly-glass. The jungle in the meshes of a damp towel. Van Leeuwenhoek, pioneer of microscopy. The flora of the atmosphere. The nature of molds. Simple apparatus used in mold-culture. The life history of a fungus spore. Important difference between green plants and colorless plants. Why fruit decays, and how decay may be prevented or delayed. The effect of cold on molds. Why cold-storage fruit decays more readily than fresh fruit. The molds that prey on the human body. Ringworm. Aspergillus. What the molds do for us in the matter of flavors.

IN the springtime, when Nature awakens from her winter's sleep, the disciples of Linnæus become unusually active in their quest for the flowery treasures of wood and field. Over hill and dale they roam, peering eagerly under fallen leaves, searching every secluded nook and bowered fastness, wandering by joyous brooks and rippling streams, in open meadow and sheltered vale, seeking everywhere the tiny, perfumed ambassadors from the kingdom of flowers. And when the floral beauties are safely transferred to the tin boxes of the collector, comes the interesting work of classification and mounting for the herbarium. Such is botany as it is commonly known. And yet there is another kind of botanical research, that may be carried on at all seasons of the year, and in the queerest and oddest places imaginable.

Imagine a botanical excursion to one's cellar, or refrigerator, or attic! What would you think of preparing calmly for a botanical outing, not through fragrant wood and dell, all out of doors, but among the crevices and crannies between the teeth of your own mouth? What would you say to a delightful afternoon spent in the fuzzy forest on top of the jelly and preserves? How would it suit you to spend a half holiday in exploring the tangled jungle of a mildew on the damp towel you so carelessly crumpled up the other day and threw into a corner? The strange plants, for plants they surely are, that flourish in such outlandish places, outnumber by a thousand-billion fold the higher forms to be seen in meadow and garden.

Away back in 1683 the quaint old Dutchman, Antonius van Leeuwenhoek, examining with a microscope a bit of tartar scratched from his own teeth, noted with immense concern and disgust that it contained millions of "animals," as he called them, "moving in the most delightful manner, and that they numbered more than were human beings in the United Netherlands."

This discovery of van Leeuwenhoek was reported to the various scientific societies of the day, but none of them paid any attention to it until about the middle of the nineteenth century, almost 200 years later. These "animals" are plants—microbes in fact. The flora of the atmosphere—the molds, the yeast, and the bacteria—are of paramount importance in the life history of the globe, and the story of their uses and dangers, their nature and their life habits is interesting to all.

The Anglo-Saxon word for dust is "molde," and it is well named, as wherever there is dust, and that means everywhere, there are molds, the skeletons in the closet. These skeletons are not in appearance at all like the grisly variety we see in the surgeon's office; but some of them are infinitely more harmful than those bleached remnants of humanity. In appearance they are as beautiful and as perfect as the violet or the wild rose, and the botanist who seeks for them may find as much pleasure in their collection and identification as he does in garnering their cousins of meadow and hedgerow. A bit of damp bread exposed to the air for a few minutes, and then placed under a bell jar, will in a day or two furnish one with ample material for research. A bewildering forest of thread-like forms, possibly as white as fresh fallen snow, will appear and mayhap after a few days turn green, blue, red, black or brown, with the production of untold millions of tiny spores which become liege subjects of the vast kingdom of dust.

The great conservatories located in the principal cities of the world afford pleasure to hundreds of thousands of flower-lovers every day in the year. And yet it is possible for everybody to own a private conservatory containing thousands of times the number of plants to be found in the magnificent collections secured to the people through public or private munificence. And these private conservatories would not require much outlay, so far as expense is concerned, nor would it be necessary to send collectors to Asia, Africa or Australia to procure material.

The conservatory itself would not be immoderately expensive. In fact, half a dozen bell jars would suffice. And the material would be a bit of cheese, a scrap of bread, a piece of old leather, some old clothes, a fragment of decaying wood, a few berries, an apple whose skin is broken, a banana, a lemon, a little jelly, and some water. Here we would have abundant material for a collection far exceeding in number of individual plants, at least, the more pretentious affairs that are dignified by the high sounding name of "conservatory."

We would not have to employ gardeners and attendants. The dust in the air would attend to all the sowing that is necessary. All that would have to be done would be to see that the temperature does not go too near to the freezing point, nor too high above the normal.

A mold is a colorless plant. It has within its cells no chlorophyll—the green coloring-matter found in ordinary vegetation—and hence is unlike such plants as trees or shrubs or grass. A green plant has the power of elaborating inorganic substances, such as nitrogen, carbon and water, into organic substances, such as starch and sugar, oils and proteids. A colorless plant is a fungus and must subsist on organic matter prepared for it by some other plant or animal. Because they must have a host to provide them with nourishment, they sink to the level of parasites, and become the rivals rather than the friends of animals.

The common toadstool is a fungus, as is the mushroom. These forms are much higher than the ordinary mold; yet they all possess many points in common, chief of which is their absolute inability to prepare a meal for themselves.

The life history of a mold is quite interesting. It starts with a tiny spore, so small and so light that it floats readily in the atmosphere and is carried without

A Piece of Bread Upon Which One of the Common Molds (Mucor) Is Growing

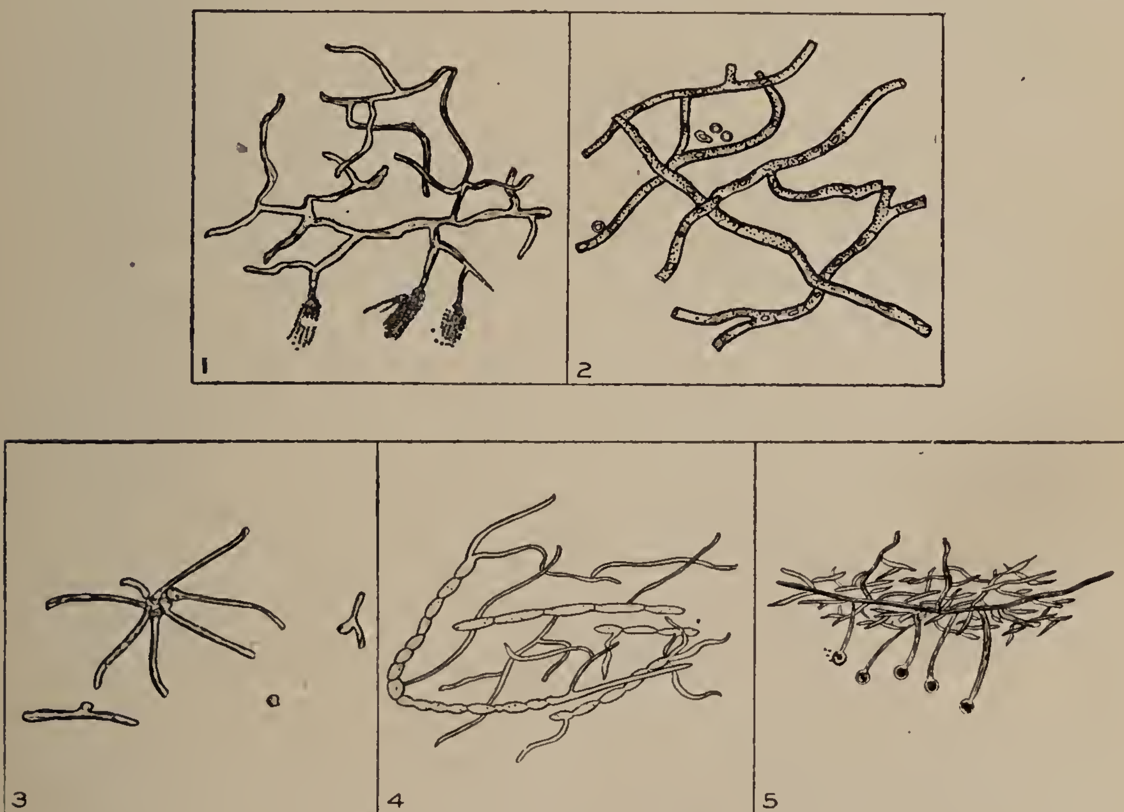
the least difficulty from place to place. This spore finds a resting-place on a bit of damp bread or other host. Soon it sends forth a tiny white thread that makes its way into every part of the material. This thread, called the mycelium, branches out again and again, until the whole substance is permeated. This permeation is easier in the softer foods like bread and cheese, and much more difficult in compact bodies like leather. The threads within the body of the material are exceedingly fine. On the outside of the mold-invaded matter, a delicate growth of hair-like threads soon appears. This growth is generally pure white, but changes within a few days to

Common Mushrooms (Edible Fungi)

black, blue, green, red or brown, depending upon the species of mold that is present. The formation of the spores, the completion of the life cycle, is quite simple.

Professor Conn, in describing the production of the spores of the common blue mold, says:

"After the mycelium has grown for some time, there arise from its surface tiny threads growing vertically into the air. These threads, after extending for a short distance, divide into little branches with several of the branches arising from a single stem. After these branches have grown for a short distance, they begin to be divided by slight constrictions, like rings, around them, so that each one of them looks like a string of beads. These rings cut deeper and deeper into the branch until finally it is broken up into a string of a dozen or more small balls. These little balls are the spores. When seen under the microscope they appear quite transparent, but when a considerable number of them are together, they have a bluish tinge. The spore-bearing branches spring up in thousands all over the mold, and after a few days its surface is covered with



Various Forms of Mold

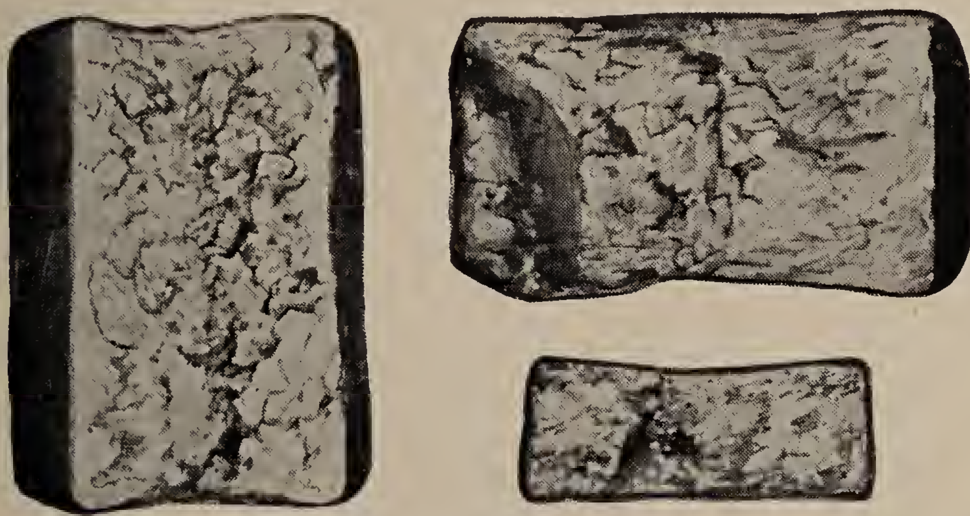
1. Mold Showing Spore and Spore Cases. 2. The Mold that Produces Ringworm. 3. Growth of Mold from Spore. 4. A Common Mold in Apples. 5. The Common Blue Mold.

a mass of thousands of spores, giving the mold first a slight blue color, and later a darker blue, until the entire surface finally becomes covered with the well known shade spoken of as blue mold. These spores are extremely light, are very easily blown by the winds, and readily float in the air. Every breath of air striking a mass of molds in full fruit will detach some of these minute spores and blow them away."

Most molds are harmless to man, although they cause him considerable annoyance and expense in that they prey upon his food. When a housewife happens upon a dish of vegetables invaded by mold, she presumably gets rid of it by throwing it into the garbage-can. Molds are likewise the enemies, or rather the intimate friends, of all kinds of fruit, and if moisture, which is absolutely essential to mold-growth, be present, apples, pears, lemons, berries, oranges and bananas soon "rot," as it is commonly termed. This can be prevented to a certain extent by keeping the fruit dry and the skin unbroken. Fruit, however, contains such a high percentage of water that, as soon as the mycelium finds its way through a crevice in the skin, the fruit itself will furnish all the moisture needed for the rapid growth of the mold.

Fruit merchants are aware that they can keep apples and other fruits far into the spring by frequent rubbing and polishing. This is impossible in the case of thin-skinned berries, which readily fall a victim to the rapacious appetites of the different molds.

For a number of years past the Division of Pomology of the United States Department of Agriculture has been studying the problem of the "blue mold" in connection with the citrus fruits of California. Everyone is familiar with the bluish or bluish-green mold that attacks the oranges and lemons. This mold, until within the last few years, cost the fruit-growers of the Coast about a million dollars per year. If the skin of an orange



Pieces of Stilton, Roquefort and Camembert Cheese
The Dark Parts are Masses of Mold Spores

or lemon is uninjured, the spores of the blue mold are powerless to do any damage. But let the fingernail make but the slightest cut in the tough skin, or let the fruit be scratched by nail or stone or splinter of wood, and the orange or lemon is doomed. Immediately the spore takes advantage of the open doorway, and starts a private conservatory of its own, causing the fruit to rot in short order. Careful handling and careful packing are the only safeguards. Since the fruit-growers of California have learned this costly object lesson, they have reduced by nearly 75 per cent the drafts made by the blue mold on their checking accounts.

It is well known that cold storage, slightly above the freezing point, will check mold-growth, but this is not an absolute preventive, as some molds grow at very low temperatures. It is also known to the housewife that fruit that has been in cold storage for a considerable time will "decay" more readily than fresh fruit. This is accounted for by the fact that apples and other fruits, after they have been thoroughly chilled by cold storage, will, when they are brought into a warm place, rapidly condense upon their surfaces the water in the atmosphere. This dampness or dew furnishes the spores with a start, and the fruit will rot, unless the surface is frequently wiped dry.

There are several molds that are daring enough to feed upon man himself, and the most common of these is the well known ringworm. The name would suggest an animal as the malefactor, but there is nothing of the animal in a ringworm, except the name. It is a plant, pure and simple, and cousin to the fuzzy molds so common on the tops of jellies and preserved fruits. Another mold that attacks the human body, and produces results far more serious than ringworm, is known as "Aspergillus." It has a decided preference for the ear, and sets up an irritation that causes considerable pain, and, if neglected, serious damage. Aspergillus sometimes attacks lung tissue that is slightly diseased, and the highest skill of the trained physician is needed in such cases to counteract its effects or to utterly destroy it. Fortunately for us, the man-eating molds are not so common as the other kinds, and since it is by molds that we get the rich flavors of Roquefort, Stilton, Gorgonzola and Brie cheese, so eagerly sought for by epicures, possibly we can call the account squared between man and the Skeleton in the Closet.

CHAPTER VII

THE FRIEND OF THE HOUSEWIFE

The "little folk" in the dust. The size of yeast plants. Difference between "wild" yeasts and the cultured varieties. The nature of leaven. When the yeast plant was discovered. The progeny of a single yeast cell in twenty-four hours. The "wild" yeasts are mischief-makers. The story of the genesis of King Alcohol. Preparation of alcoholic beverages—gin, beer, wine, brandy, rum, whisky, cider. Alcohol as a sociological factor. The chemistry and physics of bread-making. How failures in bread-making may be accounted for. The superiority of the compressed form of yeast. The importance of proper temperature in yeast cultures.

WHO of us, in the golden days of youth, has not been charmed with the wonderful stories of brownies, fairies, elves, dwarfs, and others of the "little folk," who did all sorts of household tasks for the poor shoemaker while he slept? With what eagerness did we listen to the accounts of the washing of pots and pans, of the setting to rights of untidy kitchens, the brewing of foaming ale, and the baking of untold loaves of bread? And how delighted we were with the shoemaker's consternation and perplexity when he came down in the morning and found all these things done! And we chuckled with glee when we felt that we knew more about it than the shoemaker did, and that he had not noticed the scurrying away of the little folk as soon as they heard his step on the very top stair.

The Kingdom of Dust is made up of little folk, and some of them are eager to help the housewife in her manifold duties. Indeed, she could not get along without them, as they make her bread spongy and light,

The Housewife Runs a Private Distillery Every Time She Bakes

furnish her with good, sour vinegar, and manufacture all the alcohol that is made in the world.

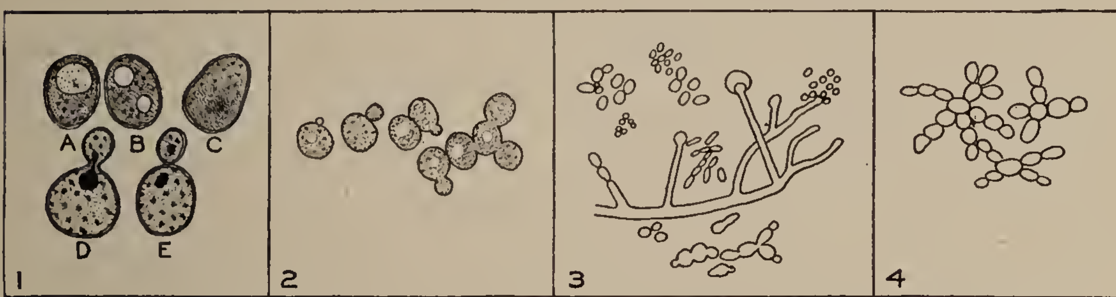
These little folk—and they are really very small, as 2,800 can find plenty of room on a thread one inch long

—are the chemists of the Kingdom of Dust, and they are the most efficient chemists in the world. They do not charge enormous fees for consultation, and they are always at hand, ready for work. In fact, we can buy a whole university of them for five cents at the nearest grocery. They come in very small cakes wrapped in tin foil, and every cake contains millions of these erudite chemists, known to us as yeast.

These compressed tablets are what might be termed the aristocrats of the yeast family, to distinguish them from the wanderers and tramps known as "wild" yeast, which are scattered everywhere in the atmosphere, and have no regularity of lineage or habits of life. Compressed yeast is literally the "cultured" variety of the yeast tribe, and is made up of strong, healthy plants that are known to do the very best work, and to produce no unpleasant results in the way of making sour bread, or causing other mischief, as their wild brethren of the atmosphere are so prone to do.

Yeast plants have been with us since the beginning of things terrestrial. They worked and slaved for our ancestors back in the dim twilight of the remote past. The Bible tells us of "leavened" and "unleavened" bread that was made over thirty centuries ago, and no doubt our prehistoric forbears of cave and cliff were familiar with the wonderful thing that happened when fruit juices were exposed to the air. Every tribe of savages has known from time immemorial how to make intoxicants of one kind or another. Leaven is yeast, and practically all intoxicants are produced by yeast.

The yeast plant was first discovered by a Dutch microscopist about two hundred years ago, but it was not until nearly the middle of the nineteenth century that the systematic study of these minute organisms was taken up, and their functions and habits of life understood. Yeast plants are known as the "budding" fungi, unlike bacteria which reproduce by self-division or fis-



1. Common Yeast Highly Magnified; A and B Show Vacuoles; C, a Nucleus Inside the Yeast Cell; D, a Budding Cell with Nucleus Dividing; E, the Cell Divided. 2. Growing Yeast Cells, Showing Budding and Forming of Groups of Cells. 3. Organisms Found Upon the Skin of a Grape and Concerned in Fermentation of Wine. 4. Cerevisiæ from Beer

sion. Sometimes, under adverse conditions, yeast will produce spores, but ordinarily the habit of reproduction is by the growth on the parent cell of a bud that afterward separates to form a distinct plant.

These minute members of the vegetable kingdom reproduce with great rapidity, as one single cell may be the parent of millions in twenty-four hours. Yeast spores may be found anywhere on the globe. Every puff of air may be laden with dried scions of this humble but important family, and every breeze may carry whole colonies, seeking, like the Pilgrim fathers of old, a new abode. When they finally come to rest in a place favorable for growth, they start into business at once, and a yeast factory is formed on the spot.

The yeast in the atmosphere, as has been said, is known as "wild" yeast, and from its many different varieties man has selected a few that have proved themselves to be the most suitable for his purpose, making careful cultures of these special forms. Some of these wild yeasts are inclined to mischief, and give a bitter or sour taste to whatever they infest. Man has therefore taken suitable precautions to educate and train only those that are free from such propensities. Otherwise, they would perform such tricks on the good housewife as giving an excessively sharp, pungent taste to her preserves, her jellies, her canned tomatoes, and her maple sugar. Ordinarily, however, any material that contains a high percentage of sugar is immune from the ravages of these atmospheric marauders, as a yeast cannot thrive where there is a large excess of the substance so dear to the palates of children.

The question that now has to be answered is: How does the yeast plant do all these wonders? All we can say in answer is that the yeast plant is an individual to whom has been given a single talent. And that talent is the power to break sugar into two simpler substances, both of which are of the highest importance to man. One of these substances is known as alcohol; the other is carbon-dioxide gas. Let us consider for a moment the simple chemical changes involved, and learn just what the yeast plant does to bring about such wonderful results. Grape sugar is made up of 6 parts of carbon, 12 of hydrogen and 6 of oxygen. Suppose we put a little of this in a dish of water, and let the yeast enter. This is what happens:

$$\underset{\text{(Grape Sugar)}}{C_6H_{12}O_6} + \text{Yeast} = \underset{\text{(Ethyl Alcohol)}}{2\,C_2H_5HO} + \underset{\text{(Carbon Dioxide)}}{2\,CO_2}$$

Here we have the story of how cider becomes "hard," how grape-juice turns to wine, and how barley turns to beer. But we are not through with the chemical changes. Everybody knows how easily and speedily "hard" cider and wine turn sour. We shall have to hold the oxygen of the atmosphere responsible for this radical change. Here is the story:

$$\underset{\text{(Ethyl Alcohol)}}{C_2H_5HO} + O_2 = \underbrace{\underset{\text{(Acetic Acid)}}{HC_2H_3O_2} + \underset{\text{(Water)}}{HO_2}}_{\text{VINEGAR}}$$

Alcohol, old King Alcohol, comes to us, then, from the dust, just as he does his best to bring us all there. Crush an apple, or a grape, or any other fruit containing sugar, and stealthily there creeps into the sweet mixture, generally from the skin of the fruit, a tiny wild yeast spore. Then with wonderful rapidity the yeast cells multiply, and presently start an alcohol factory. The apple juice turns to apple wine, and the grape juice also ferments. The flavor and bouquet of the wine, likewise, depend largely upon the variety of yeast that causes the fermentation. The best wines and champagnes of the world come from very limited areas, simply because the special wild yeasts that bring about the chemical changes are, for some curious and obscure reason, to be found only in those places.

Beer, ale and wine do not contain a very high percentage of alcohol, but by distillation the alcoholic content may be concentrated, and brandies and whiskeys are the result. Gin is prepared from juniper berries, rum from fermented molasses, brandy from wine, whiskey from rye, corn, wheat or potatoes, peach brandy from peach juice, and absinthe from wormwood. Even such a mild, sweet-smelling herb as mint is forced to give up, through the agency of the yeast plant, an alcoholic preparation known as crème-de-menthe, which, in spite of its high-sounding name, is as arrant a poison as all the rest. If the yeast plant were a sentient being, burdened with a conscience, we wonder how it would feel as the one individuality responsible for the presence of alcohol in the world. If there were no yeast plants, there would be no alcohol unless the chemists, in their desperation, should attempt to synthesize it from water, soot, and a little hydrogen gas. If there were no yeast plants, there would be no saloons, no breweries, no drunkenness. There would be no frightful roll of murders and other crimes committed by man while under the influence of alcohol. Poorhouses and penitentiaries would disappear almost to the vanishing point, were the Kingdom of Dust to lose only the yeasts from its untold myriads of subjects. It is quite a stretch of the imagination to see a saloon and a penitentiary in a few motes of dust, but if we only look hard enough, and with the proper focus, we shall surely see all of these resultants of strong drink in every beam of sunlight twinkling with its millions of dust particles.

Let us not dwell upon this function of the yeast plant, if we intend to portray the "Friend of the Housewife," but let us turn our attention to the other by-product of yeast, namely the carbon-dioxide gas, which is the real helping friend to the woman whose aim it is to make good bread.

Bread-making is almost as old as the hills, but it is the tiny yeast plant that is responsible for the bread's spongy lightness and its delicious flavor. For thousands of years the faithful fungus has toiled incessantly where yeast has been used in the making of bread. The housewife makes up a batch of dough with flour, potatoes, water and yeast. Then the yeast begins its work of fermentation. Countless thousands of little bubbles of gas are formed that push the particles of dough farther and farther apart, until the "rising" is complete. Then comes the heat of the oven, which hardens the distended walls of dough; the gas escapes with the alcohol, and the bread is made. It is just as well for the peace of mind of the housewife that she does not know she is running a private distillery every time she bakes. Should she attempt to collect the alcohol she has distilled, and keep it from escaping up the chimney, a paternal and kindly government would take a special and abiding interest in her, even to the extent of boarding her at its expense.

In bread-making there are certain details that are essential, such as a proper temperature for the oven, thorough kneading of the dough to scatter the yeast cells uniformly, a limit on the time it should stand before baking, and the prevention of "chilling." Otherwise disaster will result, and the bread will be "holey," heavy, or sour. Sometimes a wild yeast finds its way surreptitiously into the dough with its tame brethren of the atmosphere, and an evil, decidedly unpleasant flavor, is sure to be the outcome. The careful housewife does all in her power to prevent this, and carefully wraps her batch of dough in blankets as though it were a child. It is well she does so, as the wild yeasts are thereby prevented from making their entrance, and the tame yeasts are protected from a congestive chill.

There are many varieties of yeast, and it was formerly a serious matter for the housewife to get just what she wanted. She was often compelled to manufacture her own yeast, and occasionally she struck a bad lot of unprincipled urchins of the yeast world, with the result that all the men folk of her household growled most vigorously at the unusual flavor of her bread. Sometimes she went to the brewer's for her yeast. Here again a peculiar flavor would result that is not pleasing to some palates, and, besides, brewer's yeast is too slow in acting.

Occasionally she would make up a batch of Scotch "barms," as it is termed, from flour and hops. Unfortunately, however, wild yeasts appear to be especially fond of this mixture, and create havoc with the flavor. As a last resort she would be compelled to fall back upon the old "salt-rising" process, where common salt is added to milk and placed in a warm place for a few hours. The wild yeasts start to work in the mixture, and it soon froths from the abundance of carbon-dioxide gas produced. The salt interferes with the production of flavor-producing bacteria, and possibly has some obscure effect on the yeast itself. At any rate, it is just as unreliable, under certain conditions, as all the others.

With the coming of compressed yeast and dried yeasts, however, all these difficulties are practically overcome. Compressed yeast is really derived from wild yeast, and is obtained in large quantities from distilleries. The objectionable vagrant yeasts are practically eliminated, and a pure culture of the best kinds obtained.

It may be interesting to note that the Viennese bakers, who are said to make the best bread in the world, prepare their yeast from a mixture of three kinds of grain: Indian corn, barley and rye (all sprouting). These grains are finely powdered, and macerated in water at the temperature of 120° Fahrenheit for several hours. Yeast of the kind most desired thrives best in this mixture and at this temperature; it soon forms a thick scum that is carefully skimmed off, dried, and hydraulically compressed for future use.

CHAPTER VIII

THE RIGHT HAND OF DEATH

Popular misconception concerning tuberculosis. Bacteria are plants, microscopical in size. Their immense numbers and varieties. The aggregate mass of microscopical forms greater than the aggregate of all other forms of life. The three great classes of bacterial life. How bacteria move. The difference between bacteria and other fungi and the yeasts. How "fission" and "budding" differ. Experimental culture of bacteria colonies. Bacteria cause three classes of disease. The nature of an anti-toxin. How tuberculosis destroys its victims. Isolation the only hope. Laws concerning the disposal of sputa and other excreta.

MOST of us are familiar with the beautiful and artistic conception of French, wherein a young sculptor plying his magic chisel upon a block of stone, and summoning from the snowy depths of the marble the dream face of his soul's ideal, is gently touched by the wistful-eyed Angel of Death, and the skillful arm forever stayed. The whole creation is marvelously beautiful and the world is better for its birth. Nevertheless it is allegorical and misleading.

The real Angel of Death in the case of the thin-faced sculptor was not a sad-visaged maiden of classical profile. In all probability it was a minute, rod-like organism floating amid motes of dust and known to scientists as the "bacillus tuberculosis." The author does not wish to become a shatterer of ideals, but the sooner such poetic notions of death are done away with, and the mass of the people educated in a commonsense way to the dangers of dust and bacteria, the better it will be for humanity in general.

Death is often represented as a grewsome skeleton armed with a long scythe. A truer representation of the

"The Angel of Death"

king of terrors would be a round-cheeked housemaid wielding a broom and dust-cloth, or a cloud of dust stirred up by the passage of an automobile along a crowded dirty street.

Bacteria are tiny little plants, so small that 50,000 of some varieties may be placed in single file along a line one inch in length. They are barely visible under the highest power of the microscope, and there is no doubt that there are untold myriads of bacteria that are absolutely beyond the limits of definition of any microscope as yet known to science.

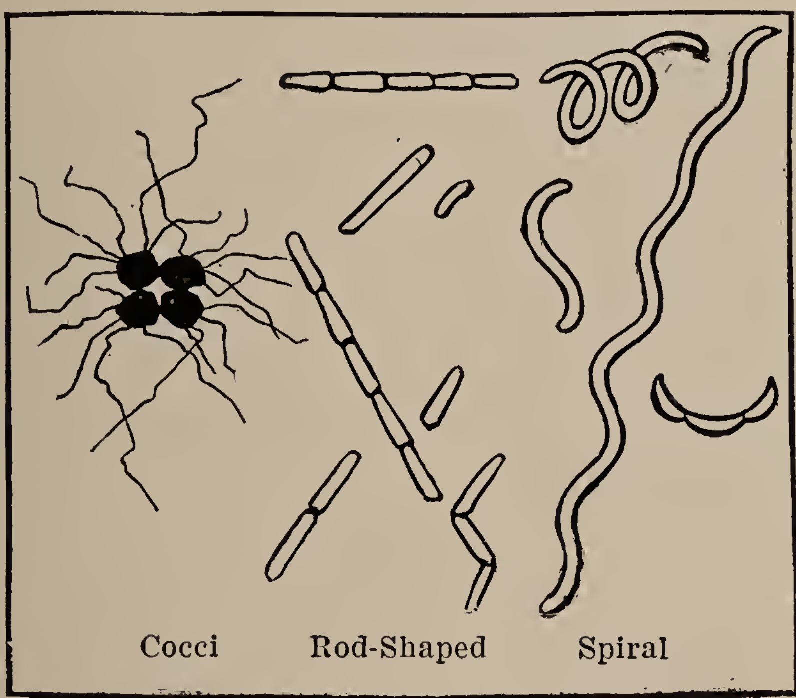
Although these bacteria are so minute, they make up in numbers what they lack in size, and if the animal life of the globe, from the elephant down to the flea, were to be aggregated into one mass, this mass would probably be far less than the aggregate of all the microscopic forms of life, animal and vegetable.

Bacteria are divided into three great classes—the spherical, known as cocci; the rod-shaped, known as bacilli and bacteria; and the spiral. It was originally thought that bacteria were animals, as some of them, such as the bacilli, have the power of moving from place to place. It is a well known fact, however, that many plants possess the power of locomotion, and it is now admitted that bacteria are plants.

This power of locomotion, possessed by many bacteria, is due to locomotor organs known as "flagellæ." The flagellæ are tiny hairs that whip and lash the fluid in which the bacteria flourish, and thus cause motion.

The simplest of all the bacteria types is the coccus. The cocci consist of tiny spheres, without the slightest evidence of any internal structure. Sometimes they form long threads or chains, while others of the same general species form irregular masses, resembling cannon balls piled into the form of a cube. The rod-shaped bacteria are, as the name would indicate, tiny rods that lengthen and break up into smaller rods, which in turn repeat the process indefinitely, as in this manner they are reproduced.

A bacillus is one of the rod-shaped bacteria that have flagellæ, and is, consequently, capable of motion; while a bacterium proper is rod-shaped, but has no flagellæ. The spiral bacteria are less often met with, and, like all other kinds of bacteria, may or may not have flagellæ.



Three Types of Bacteria Which Cause Disease

In a preceding chapter it was pointed out that yeasts and bacteria are fungi. A yeast, however, is known as a budding fungus, as the new individuals appear as buds on the older cells. Bacteria, on the other hand, reproduce almost entirely by "fission," or the splitting of the parent cells. We say "almost entirely," because it sometimes happens that bacteria reproduce by means of spores that germinate into individual bacteria. So far as human life and disease are concerned, the formation of these spores is especially important in that they are much harder to kill than the bacteria themselves. For example, they can be dried perfectly, whirled along in a cloud of dust, and be ready for active work as soon as they reach the proper medium. They will withstand greater extremes of temperature, likewise, and are therefore exceedingly persistent.

Some bacteria have the power of reproducing themselves every half hour. Let the reader sit down quietly with pencil and paper and figure out what the progeny of such a micro-organism would be at the end of twenty-four hours. In other words, multiply the number two by itself forty-seven times. One can hardly realize the frightful rapidity with which bacteria multiply unless some such calculation is made. Of course, they do not all live. Hence we live, and have some chance to remain alive.

As has been stated, the number of bacteria is legion. Fortunately for us, the greater part are harmless, and some are beneficial to man; but there are enough of the deadly kinds to more than offset the good done by the benignant types.

As regards the distribution of bacteria, they exist practically everywhere on the globe. In crowded cities, in purling brooks, on lofty mountain tops, in shaded vales, in Arctic wastes, and in tropical forests—frozen by winter's icy blasts, or baked by the withering simoon of the desert, they live and move and have their being. They are found in the ice in our refrigerators, the bread in the oven, the cream in the pitcher, the vegetables in the garden, and the meat on the butcher's stall. The human mouth may contain as many as twenty-seven different varieties of these children of the dust.

Even under the most unfavorable conditions, bacteria will thrive to a certain extent. For example, in the Bos-

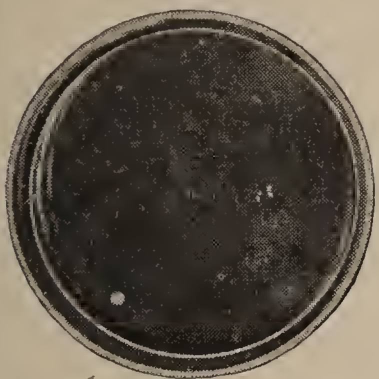


Fig. 1—Petri Plate Exposed in Lecture Hall of Fifth Avenue High School, 8 A. M., Before the Arrival of Pupils

Fig. 2—Similar Plate Exposed in Same Place at Noon Recess, Showing Mold and Colonies of Bacteria Collected

ton City Hospital, where the most rigid sanitary conditions prevail, the number of living bacteria to every cubic foot of air was found to be 1,350 and of molds, 675. In Central Park, New York, 1,500 bacteria were found in every cubic foot of the presumably pure air of that favored resort.

The number of bacteria in a given quantity of air or other container is ascertained by what is known as the "culture" method. A thin bouillon or soup is made from gelatine, peptone, and Liebig's extract of beef, or from agar-agar (a preparation derived from Iceland moss).

This medium is first rendered sterile by dry steam. It is then placed in a small glass dish known as a Petri plate, about 3¾ in. in diameter, and allowed to harden, after having been securely covered with a glass plate. These plates are then exposed for a few minutes to the air, and the dust particles settle on them. They are then closed and kept at a temperature of about 70° Fahrenheit for two or three days, when a number of colonies appear, made up of molds of bacteria. Figures 1 and 2 show the result of such exposures in the lecture-room of the Fifth Avenue High School, Pittsburg. Those in Fig. 1 were exposed for a few minutes at 8 a. m. while the room was practically free from bacteria, as the pupils had not arrived, and there was comparatively little dust. Fig. 2 shows the result of a two-minute exposure at noon, immediately after the passage of a large class through the room. The larger form in the center of the plate is a mold, while the small dots around it are colonies of bacteria.

A five-minute exposure of Petri plates on a public street where the sweepers have just passed in their unsanitary, death-dealing march, revealed the presence of 5,810 living germs in the small space of less than four inches. Possibly our city fathers may learn, some day, that the hose and not the sweeper should be used in the public highways.

Bacteria cause three classes of diseases. In the first class, of which pneumonia is the type, the bacteria enter the general blood circulation of the body and reproduce enormous numbers of the tiny plants that feed on the tissues of the organs infected, or else produce loss of function of the organ by clogging the cells. Bacteria of this class produce what are commonly known as septic diseases.

In the second class, of which diphtheria and lockjaw are the types, the bacteria, like those of the first class, settle in some part of the body, but, in addition, they produce poisons known as toxins, which are carried throughout the body. These toxins are concentrated poisons that cause cell death. The blood carries the toxin to all parts of the body, while the bacteria that produce the toxins do not leave the part of the body originally infested. It is generally conceded that a cell, once infected, must die, and the only possible hope in diseases of this class is the formation of an antidote, or "antitoxin," as it is termed. This the body can do, and very often does. Sometimes, however, it takes too long for the body to do this, and the toxins, untrammeled, poison enough of the cells to produce death. The knowledge that toxins are formed in the body has proved to be of enormous value, as antitoxins, which neutralize the poisons, have been artificially prepared. The antitoxin of diphtheria, for example, has almost wiped out this erstwhile plague of childhood, cutting down the mortality from 90 per cent to practically zero, and it is an infallible specific when administered in time.

The third class of bacteria-caused diseases is represented by typhoid fever. In this class not only do the bacteria enter into the circulation, but their toxins likewise move freely throughout the system.

Possibly Our City Fathers May Learn, Some Day, That the Hose and Not the Sweeper Should Be Used on the Public Highways

To which of these classes belongs the great white plague, the right hand of death, is not known. Curiously enough, although so much study has been given to this dread disease, tenfold more than to any other ailment of the human race, we do not know whether Koch's famous bacillus kills by multiplying in the tissues, or by producing poisons that destroy the cells.

It is needless to remind the reader of the frightful mortality due to "consumption," the older and better name for tuberculosis. Everyone is already familiar with its dread havoc. More than half of all the deaths in the world, from the equator to the poles, are due to this destroyer.

And the pity of it is that it is avoidable! If the excreta from consumptive and typhoid patients were to be destroyed, instead of being sent into the Kingdom of Dust, both diseases would in one year disappear from this planet. Consumption is dust-borne. Typhoid fever is water-borne, or milk-borne. In accordance with the germ theory of diseases, so generally accepted, if we would destroy the germs, there would be an end of the disease.

Unfortunately, the chosen places of the earth, climatically speaking, where the natural conditions are most favorable for patients suffering from tuberculosis, have become hot-beds for the growth and dissemination of this disease. By every train sufferers come to these places, there to congregate in a comparatively narrow area. Every swirl of dust in these centers of infection carries more germs than are to be found anywhere else, and it is almost a miracle when any one recovers in these nurseries of germs, the conditions, other than climatic, being so adverse. Slowly but surely mankind is learning that isolation, pure air, and good food are the only defense against the great white plague.

What shall we say of the careless men and women who deliberately eject into the public streets, highways and conveyances sputa that may contain billions of germs, which, when they are dried, shall join the Kingdom of Dust as the right hand of death? Were a man to run amuck through the crowded streets of our cities, stabbing and shooting, right and left, what would be done with him? In self-defense, one would shoot him down as though he were a beast of prey. And yet, he would be comparatively harmless, as he could wound or kill only a few people. Yet we permit well dressed men and women, educated and apparently refined, to expectorate upon the streets, although we know, absolutely know, that their sputa might be the cause of scores or even hundreds of deaths. Such unfortunates are infinitely more dangerous to the welfare of mankind than the poor madman who can at most injure only a few of his fellows.

If we are to fight the great white plague, it must be through the means given to us by science. We know the cause. We know how to stamp it out. Stringent laws concerning expectoration and the disposal of excreta should be passed by every law-making body in the world, and the people made to save themselves from the frightful punishment inflicted upon them by the Right Hand of Death.

CHAPTER IX

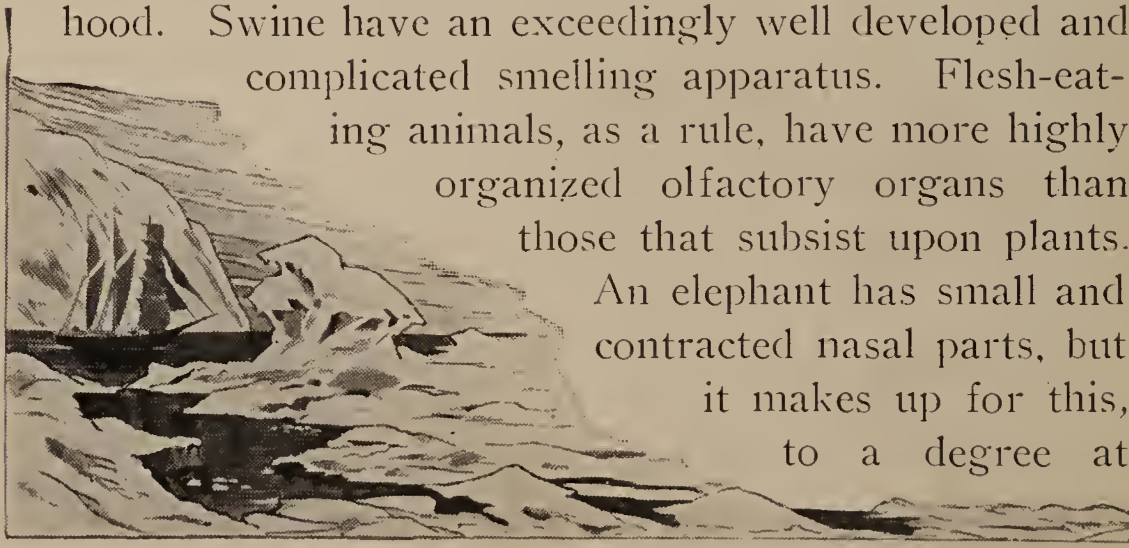
PERFUMES AND ODORS IN THE DUST

Diversity in origin of odors. The senses are highways of communication. Smell the oldest sense. Distribution throughout the animal kingdom. The olfactory organs of the lower animals. The remarkable olfactory powers of the polar bear. The mechanism in the human body upon which the sense of smell depends. The "contact" theory of smell compared with the corpuscular theory of light. Reasons for belief in the "wave" theory of smell. Electrons compared with Newton's corpuscles. The minuteness of the particles of musk capable of stimulating the sense of smell. Odors filtered through cotton. Remarkable powers of smell possessed by certain blind people. Criminals may in time be identified by their peculiar odors. A bloodhound and its quarry. Distinction between smells and irritants. Distinctions between tastes and flavors. Interesting experiment in the detection of substances by their odors. Healing power of perfumes. Antiseptic properties of incense.

THROUGHOUT the vast and mighty realms of the Kingdom of Dust, there are no subjects so welcome to mankind as those whose province it is to excite the sense of smell. They come to us in the sweet fragrance of the pine forest, the soft zephyrs that are wafted from heaps of new-mown hay, the delightful scents of garden and meadow, and the invigorating breezes of ocean shore and mountain side. Likewise, from other sources come other scents and odors, not quite so agreeable or pleasant, and with which we could well dispense.

The senses are the highways by means of which connection is established between the things that constitute the outer world and the inner consciousness that we call Self. Could we not see, hear, smell, taste, or touch, we would be lower in rank than an oyster, as even an oyster has most of these senses. Of all the senses, the sense of smell is probably the oldest, next to the sense of touch, of which, as Democritus pointed out long ago, all the senses are modifications. We find it widely distributed throughout the animal kingdom from the jellyfish up to man, and located in wonderfully diverse forms, such as hairs, antennæ, delicate tubes, cones, knobs and membranes.

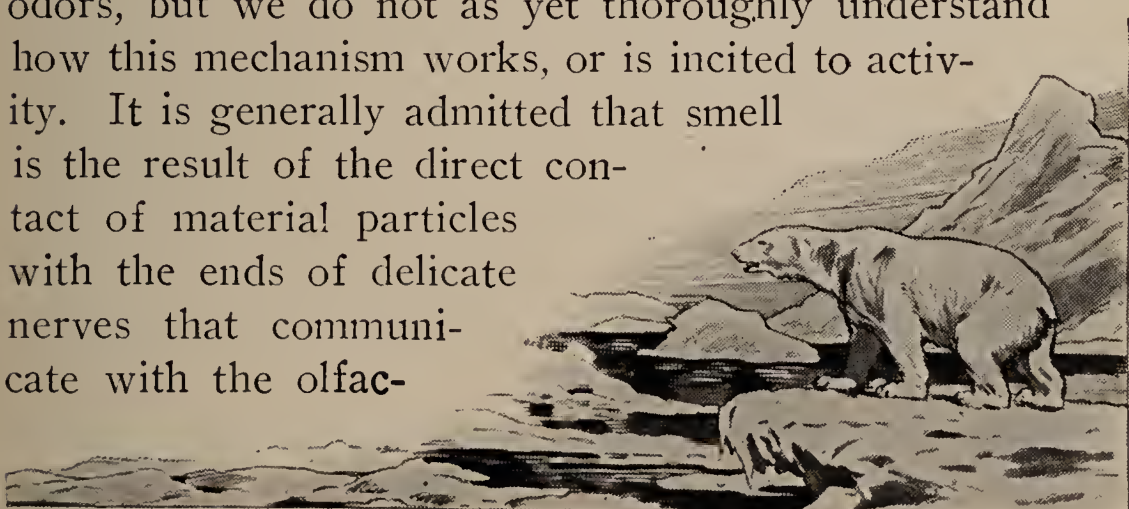
Like all the other senses, its keenness and delicacy depend upon how much it is used. A vulture, for example, has five times the smelling power of a turkey, simply because the vulture would starve if it could not detect the odor of its food miles away, while a turkey does not depend upon its olfactory powers for a livelihood. Swine have an exceedingly well developed and complicated smelling apparatus. Flesh-eating animals, as a rule, have more highly organized olfactory organs than those that subsist upon plants. An elephant has small and contracted nasal parts, but it makes up for this, to a degree at



The Polar Bear has been Known to Scent

least, in having the longest nose in creation, the nerves extending to the nostrils at the very tip of the proboscis or trunk. Curiously enough, it is quite probable that the sense of smell is entirely lacking in the largest animals that live, or ever did live—the whales. Only the whalebone whale has olfactory organs. The smelling apparatus of a bear is exceedingly complicated. The parts of its skull given over to that function, and known as the turbinated bones, are so folded and divided that they look like a section of honeycomb. No wonder the polar bear has been known to scent a ship at a distance of seven miles. The effect of certain smells, such as catnip and valerian, upon cats, is well known, producing a condition that is practically intoxication.

Although the senses have been carefully studied by the scientists of every age and of every clime, we know less of the older senses than we do of those that give us sight and hearing. We know something about the mechanism by means of which we become conscious of odors, but we do not as yet thoroughly understand how this mechanism works, or is incited to activity. It is generally admitted that smell is the result of the direct contact of material particles with the ends of delicate nerves that communicate with the olfac-



a Ship at a Distance of Seven Miles

tory bulb—a nerve center situated at the back portion of the upper nose—and transmitted thence to the base of the brain. These material particles may be in the form of a gas or vapor, as gases and vapors are, after all, only matter that is extremely divided, undoubted subjects of the Kingdom of Dust. It is supposed that these particles move about on the damp surface of the olfactory membrane, in very much the same manner as small particles of camphor move to and fro on the surface of water, and that they cause, either mechanically or chemically, an irritation of the nerve ends.

Any one who is familiar with the bitter controversy of the latter part of the eightenth century, concerning the nature of light, may take a different view of the "contact" theory of smell, as advocated by most scientists of the present day. It will be remembered that such men as Newton believed religiously in the theory that light is corpuscular in its nature, and that a beam of sunlight produces its wonderful physiological and chemical effects by the incessant pounding of myriads of tiny little particles of matter known as corpuscles. Thomas Young, an English physician and scientist, was a bitter opponent of the "corpuscular" theory of light, and on November 21, 1801, delivered a lecture before the Royal Society, in which he demonstrated the truth of the theory of Hooke and Huygens, that light is solely a form of wave motion. Since that time scientists have commonly adopted the undulatory or wave theory of light. Possibly the same revolution of ideas may occur concerning the nature and transference of odors. There are many facts pointing that way. Ramsay, the celebrated English chemist, is a believer in the "wave" theory of smell, and declares that "the sense of smell is excited by vibrations of a lower period than those which give rise to the sense of light or heat." He also states that a substance to have an odor must be at least fifteen times heavier than hydrogen gas, and that as a rule all substances having a low molecular weight have either no smell at all or else produce an effect by irritation of the delicate membranes. He further states that as the specific gravities of gases rise, their smell is increased, especially in the carbon compounds. Acids, likewise, gain in odor as the densities of their gases increase.

If the sense of smell is excited by vibrations of the ether, and not by material particles, then there are no perfumes or odors in the dust, even as light and heat are immaterial. It is a curious fact, however, that science has been compelled over and over again to reverse itself. Certain facts, lately discovered, in regard to the properties of matter, would seem to indicate that light-producing bodies give off extremely small, swiftly moving particles, called electrons, comparable to Newton's corpuscles, moving at the rate of 60,000 miles per second, or, roughly, about one-third the velocity of light. It is not difficult to prophesy that the next decade will see changes in some of the present-day theories in physics and chemistry.

It is almost impossible to conceive the smallness of the particles of dust that are supposed to emanate from a body in order to produce the sense of smell. A few

Possibly the Bertillon System will be Discarded for One Based on Smells

grains of musk will fill a house with their perfume; and yet, after years of exposure, no loss of weight can be detected by the sensitive balance of the chemist. A grain of musk may be divided into 135,000,000 parts, and each particle retains the power of stimulating the sense of smell.

An odor may be perceived after it has been filtered through a tube containing cotton. The particles that are responsible for the odor must, therefore, be less than the one-hundred-thousandth part of an inch in diameter.

As a general rule, the loss of any sense is commonly followed by an increase in the delicacy and perception of the other senses. Certain blind people have been known to have remarkable powers in the matter of smell perception. One instance is on record where an inmate of a large institution for the education of the blind was able to detect instantly the clothing of the other inmates, and to classify each garment with its owner's name, from the peculiar body smell it retained, even after it had passed through a vigorous cleansing in the laundry. It would follow from this that each of us has a certain definite odor, as distinctive as are the whorls on the balls of our fingers. Possibly our more enlightened descendants, in the dim future, will discard the present Bertillon system of finger prints and physical measurements in favor of a system based upon smells. Tiny vials, each containing the peculiar, distinctive body smell of some offender against the majesty of the law, will be filed away, in a great library of smells, for future reference.

Liegeois has stated that the smell of a corpse may haunt a living person for days, notwithstanding frequent washings and changes of clothes. Human odors are undoubtedly much heavier than the air that carries them, and do not readily diffuse. This accounts for the fact that a bloodhound keeps its nose close to the ground when seeking the scent of its quarry.

Quite frequently the senses of taste and smell are confounded. We are familiar with the fact that a bad cold in the head makes it impossible to distinguish between small cubes of pineapple and similar cubes of potato, when taken into the mouth and chewed. We mistake perfumes for tastes. Physiologists tell us that there are only four tastes: sweet, sour, salt, and bitter. We are, therefore, indebted to the sense of smell for all the other so-called tastes.

It is likewise a fact that we must distinguish between the substances that excite the sense of smell and those that simply irritate the olfactory membranes. Contrary to common opinion, ammonia gas has no smell whatever, but produces its well-known physiological effect by irritation. This is possible from the fact that the nerve ends, extremely fine and delicate, are naked and absolutely bare, not being covered with the mucous membrane as are the nerves of taste.

The sense of smell in man is not as delicate as it is in some of the lower animals. It is quite likely that we miss much enjoyment thereby. We cater most strenuously to the sense of taste, but neglect our opportunities as regards the cultivation and gratification of the equally important sense of smell. The perception of "flavors," as they are termed, is really due to the sense of smell, and has nothing to do with the sense of taste, as has already been pointed out.

Few of us know the names of more than twenty or twenty-five smells, even if we are able to distinguish them by our noses. The writer once entertained a party of fifty high-school students at his home, and, somewhat at a loss to know what to do with them, decided that the evening should be given over to the detection and perception of odors and perfumes. Accordingly he placed about sixty small homeopathic vials, each containing an essential oil or extract, such as bergamot, lilac, rose, violet, mustard, tobacco, geranium, mint, cloves, bitter almonds, nutmeg, etc., in different parts of the house. The students were given paper and pencils and were required to write the name of each odor or perfume opposite the number on the card corresponding to that on the bottle. The result was interesting, though rather disappointing. Not one of the students named half of the smells, and 90 per cent of them did not recognize, or at least name, more than twenty of them, although the odors selected were, for the most part, quite common.

The student who named the most also stood highest in her school work. Of course the test was not a fair one from the fact that the stronger perfumes prevented the perception of those more delicate. It is quite probable that a coating is produced on the membrane by the heavier oils, thus deadening it to the perception of the lighter essences.


In the Middle Ages the Burning of Incense had a Sanitary Significance

The healing power upon the human body of certain perfumes, such as lavender, eucalyptus, rosemary, wintergreen, cloves and eau de cologne, is undoubted. How many headaches have been banished by the timely use of smelling-salts! No wonder our grandmothers gathered great bunches of lavender and other sweet-smelling herbs for household use. Most of the perfume-bearing herbs are not only pleasing to the sense of smell, but are likewise antiseptic in their properties. It has been proven beyond question that the perfume from certain herbs will destroy bacteria. In the middle ages the use of perfumes prevented many an epidemic, and the burning of fragrant incense in crowded cathedrals had a sanitary as well as a religious significance.

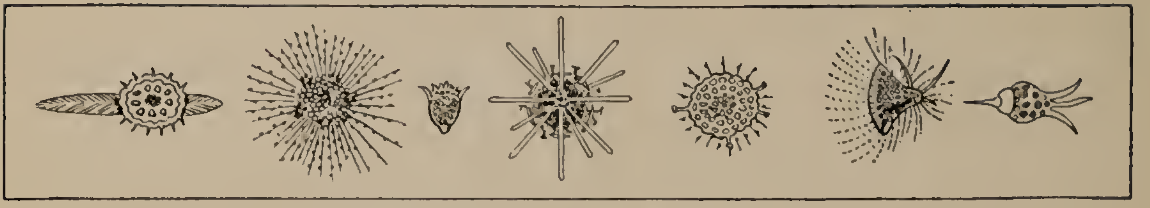
Possibly the time will come when these delightful ambassadors from the Kingdom of Dust will be given a more important position than they now occupy in the healing art, and mankind will learn to appreciate in a higher degree the scientific value of the Perfumes and Odors in the Dust.

CHAPTER X

THE WONDERS IN THE DUST

Nature's marvels, great and small, compared. The solar system a multiplication of dust units. Exquisite shells from the deep-sea ooze. The story of pollen. Variety and beauty of pollen grains. Rock sections, thin as tissue paper, and what they reveal. How crystals are formed. Household chemicals that readily crystallize. Crystal architecture compared with the handiwork of man. The messages sent to man from the crystal domain. The marvelous products of muck and slime. Bog iron ore. The origin of the ruby, emerald, sapphire, opal and diamond. Snow crystals. Flowers imbedded in ice. Hoar frost. The gradual disappearance of dust deposits known as fertilizers. The problem of reconstruction of organic compounds from inorganic materials. The coming science of synthetic chemistry. Nature's chemical magic.

WE ARE all more or less familiar with the great natural wonders of the earth on which we dwell. We have seen mighty oceans, thundering Niagaras, stupendous glaciers, magnificent rivers, tremendous volcanoes with their lakes of molten rock, immense caverns hung with snow-white stalactites, great cañons cut out of the living rock, lofty mountains crowned with eternal snow, and beautiful valleys decked with the myriad forms of plant life. Aided by the magic of the telescope, we have looked far into the abysses of space, and have seen the shining glories of sun and star and planet. Spellbound, we have watched the birth and death of



Minute Shells, Microscopic in Size, Dredged from the Ocean Bottom

worlds and solar systems similar to our own. We have gazed upon the faintly glowing nebulæ far away in the infinite realms of the starry heavens, and have been impressed with their grandeur and our own insignificance.

And yet, after all, these marvelous things are but a few of the wonders of the universe. The microscope, with its wonderful eye of crystal, rivals the telescope in its power of revelation. A handful of dust is as wonderful as a solar system if we rightly interpret the evidence it presents of use, perfection of design, and the working out of laws that are as stupendous and eternal as those that brought forth a Sirius or a Pole Star. A continent, indeed, is simply a combination of certain subjects of the Kingdom of Dust, while the sun itself is naught else than a glorified multiplication of dust units.

Let us, then, pick up a handful of dust, here and there, place a few particles under the objective of a powerful microscope, and become familiar with some of the wonders in the dust.

The first handful we will take from the ooze at the bottom of mid-ocean. It is a slimy, disagreeable mass of mud, when viewed with the naked eye. Under the microscope these deep-sea dredgings resolve into the most beautiful forms imaginable. They are really the

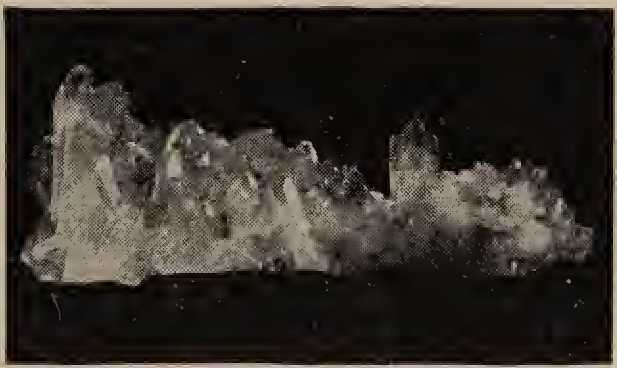
Pollen Grains Assume a Wonderful Variety and Beauty of Form

shells of minute organisms, vegetable and animal, and are made up of tiny bits of lime or silica woven into forms of exquisite beauty and coloring. Millions and millions of these fairy-like creations have been determined in a single cubic inch of ooze! Each of these mites of creation is as perfect, complete and individual as an oak or an elephant. Delicate domes are here, more wonderful than Michael Angelo's famous dome of St. Peter's. Windows and door-ways, made from sand or lime, far more beautiful than those of any cathedral wrought by the hand of man. Palaces rich in ornament and tracery, formed from the dust in the water, by animals and plants without a vestige of brain, lie desolate upon the bottom of the sea, abandoned ages ago by the tiny inhabitants. Structures more marvelous in their sculptured witchery than the famed Colosseum, the Pantheon, or the Taj Mahal, are buried in the ooze and slime at the bottom of every sea. Exquisite creations, infinitely more graceful in design than the storied marble of a Phidias or a Praxiteles, lie in wanton waste in the foul mud of the ocean depths.

Let us take another handful of dust from garden and meadow. Under the microscope we find this to contain thousands of curious forms known as pollen grains. It is a well-known fact that practically all the flowering plants emit from their anthers a powdery dust that is of vital importance in the life history of the vegetable kingdom. These pollen grains are carried either by insects or by the wind to the stigmas of other plants, or of the same plant. Here they at once proceed to send long tubes down to the ovules hidden away in the lower part of the pistil, and fertilize them into true seeds. While the whole process is wonderful, it is the variety and beauty of form displayed by the various pollen grains to which we would especially ask attention. The illustrations show a few of the many different kinds. Some of the grains are perfect globules, others are cubes or ovals. Some are wonderfully lobed or have bladder-like appendages to assist in the transportation of the pollen by the wind. Some are covered with bristly points like diminutive spearheads. Others have delicately wrought smooth bands or spiral groovings. So specific are these markings that it is possible to recognize many plants by the pollen alone. They are as characteristic and individual as human beings themselves, and yet, they are after all but insignificant motes of dust.

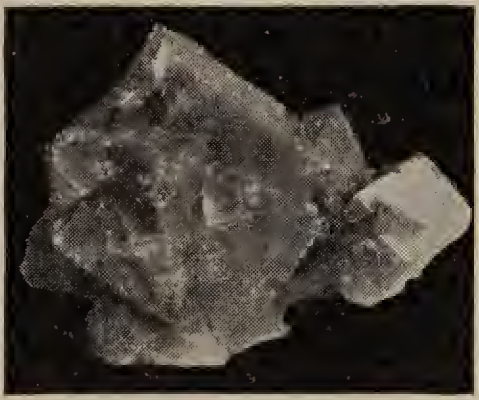
For our next handful, let us scrape off a few bits of the weathered granite, limestone and sandstone of any mountain side. Let us take them to the laboratory and grind the tiny fragments so thin that we may see through them. Under the microscope, these paper-thin rocks tell us all about themselves, and their story is wonderfully interesting. Even the mountains, so say the rock sections, are subjects of the Kingdom of Dust. These delicate films of rock enable us to look directly into one of nature's private laboratories, and we see the various particles of quartz, mica, feldspar, limestone, hornblende and other rock material summoned from the disorder

Crystals—Black Tourmaline in Quartz



Quartz Crystals

Crystallized Sugar—Rock Candy



Crystals Fluorspar

Various Crystals Built from the Dust

and chaos of the dust heap and marshaled into the beautiful and symmetrical forms known to us as crystals.

And now we must digress a little from the main subject in order that we may review our knowledge of the wonderful process known as crystallization. If we place a few grains of sugar in a small quantity of water, and let the mixture stand undisturbed for a few days, a queer thing takes place. Slowly but surely each tiny particle of sugar, moving about in the solution, makes overtures to the other particles looking to a combination. If a thread be placed in the concentrated liquid, the process of crystallization goes on apace. Little by little the opaque sugar, particle by particle, takes hold of the life line thus thrown to it, and attaches itself either to the thread or to other particles that have already gained a hold upon it, and forms crystals, beautifully symmetrical and transparent.

Imagine a mob of men running wild over a vast field. Suppose that these men were suddenly to fall into line like well-trained soldiers. Suppose that these men were to form, at the word of command, into the most perfect geometrical figures, star-shapes, pyramids, squares, hexagons, octagons, or even cubes bounded by lines and angles that are mathematically perfect. Suppose, also, that some of these men, wonderful to relate, should become perfectly transparent or translucent, either colorless or tinted a beautiful violet, blue, green, lavender, orange, pink or brown, and that others should remain opaque. Would not all this be ridiculed as an impossibility or the dream of a poet? Nevertheless, it is precisely what happens when certain substances are permitted to dissolve and to follow the unerring laws of a sovereign of which they are the lieges.

Anyone may readily become familiar with the many curious facts that are associated with the phenomenon of crystallization. Practically all of the household chemicals, such as sugar, salt, baking-soda, washing-soda, copperas, cream of tartar, etc., will answer the purpose. Dissolve any of these substances in a small quantity of boiling water, and let the mixture cool and slowly evaporate. In a few hours, or at most, in a few days, characteristic crystals will form, more beautiful than any illustration that could be put on printed page. If all the substances are mixed and dissolved, crystallization will go on just the same. Each of the salts will form separate communities of crystals. Each sort will seek its own kind with something that is marvelously akin to intelligence. If we enlist the chemist's aid in our search for crystal material, and secure other chemicals, such as blue vitriol, bichromate of potassium, alum, hyposulphite of sodium and nitrate of silver, we shall add greatly to the beauty and completeness of our home-grown collection of crystal treasures.

In all this wonderful world of ours there is surely no process more wonderful than that of crystallization. If architecture is "frozen music," as Madame de Staël so aptly said, then crystals must be frozen thought. Their study opens up an enchanted realm wherein fairy princes, gnomes and dwarfs work their will, building beautiful things out of the lowly dust. In many respects a crystal in its life history resembles a human being. As Ruskin pointed out, long ago, there are crystal virtues, crystal faults, crystal quarrels, crystal joys and crystal sorrows, if we read aright the messages the crystals have left for prying mankind to interpret and understand. They tell us of ambition, emulation, caprice, activity, rest, weakness, strength, pride, success and failure. Do we find much more than this in the life story of the average man or woman?

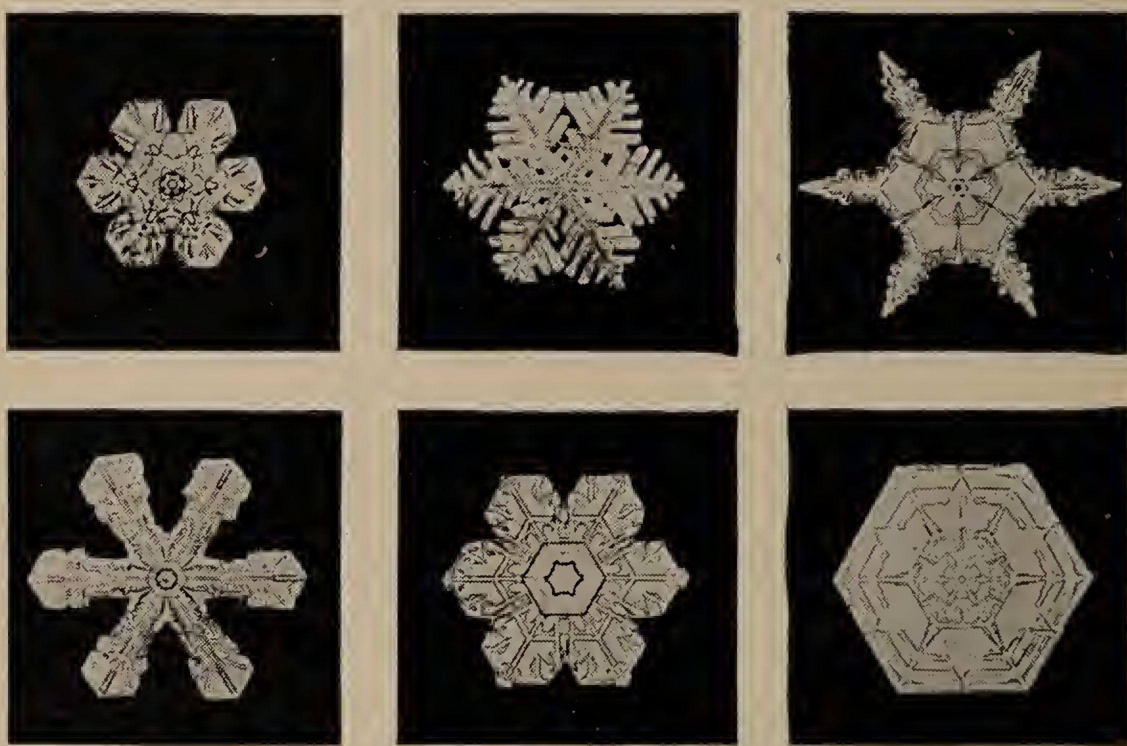
Let us take our next handful of dust from the black muck and slime of a swamp or bog. Surely nothing could be more uninviting. Instinctively we associate it with death and decay, forgetting the ancient delights of mud-pie days in the long ago. And yet this muck and slime has a story to tell just as marvelous as that told by the deep-sea dredgings. Besides the water present, there are at least four different materials in this handful of "filth" from the bog. The surprising part of it all is that no one would ever imagine that these substances were there, after we have sorted them out and told the story of their possibilities.

The mud contains tiny particles of iron, clay, sand, and soot, or carbon. How did the iron get there? Have you ever noticed an iridescent film shining on a pool of stagnant water in a woods? Undoubtedly you have, and thought it to be a scum of petroleum. On the contrary, this film has nothing whatever to do with oil, but owes its presence to tiny particles of iron oxide that were leached out of the surrounding soil, carried by little threads of water trickling through the forest floor, and deposited in a pool where it eventually was laid down as bog iron ore. Billions of tons of iron ore have been deposited in this manner throughout the earth's crust. Therefore, the first of the wonderful things that we are to notice in this handful of muck is iron with all its potentialities of steel steamships, skyscrapers, bridges, boilers, and rails that will one day crisscross a continent.

Let us now consider the next ingredient in our handful of mud, the clay. This is the plastic substance that we readily detect by kneading the mass with the fingers. Crystallization will work wonders with this sticky, coherent substance. Obeying the wonderful law of unity, as Ruskin has told us, the clay particles will separate from the other constituents and form the beautiful white material from which our finest porcelain and chinaware are made. More than that, if left to itself, the clay may crystallize into a substance that is harder than flint, and of a beautiful red, green or blue color—a ruby, emerald or sapphire.

The gritty substance in the mud is sand, and when this substance likewise enters the mystical crystal kingdom it forms the precious opal. The carbon, not to be outdone by the clay and sand, casts aside its mantle of sooty darkness, and through the magic power of old Mother Nature may become a diamond. This handful of dust, then, has turned out very well, in that it has given us iron, the most useful of all the metals, and a glittering cluster of the rarest gems—and all from the mud we are so careful to avoid lest we soil our shoes or clothing with it!

Let us take one more handful of dust and "tell its fortune." This time let it be water-dust—snow is its ordinary name. Everyone, surely, is familiar with the exquisite beauty of the snowflake. Formed as they are on the general plan of a hexagon, no one ever saw two snow crystals precisely alike. Nature sends out billions and billions of her snow handiwork, but every crystal is individual and peculiar. She delights in variety, and truly the snowflakes are not the least of the wonders in the dust. Even in a cake of solid ice one may see the



Photomicrographs of Snow Crystals

delicate, beautiful snow flowers packed closely together, for the ice is simply one mass of these marvelous products of nature's art gallery.

Floating lazily in the clear blue reaches of the sky are other examples of the wonders of water-dust. The glorious clouds, like fabled castles filled with dream folk, are either tiny drops of water, or minute crystals of ice soaring far above the busy world below. Sometimes these ice crystals cover trees, window-sills and grass with their beautiful spicules of hoarfrost, and everyone knows what a famous artist Jack Frost is in the matter of window ornamentation.

Photomicrographs of Frost and Ice Crystals

One other thought, and then we are done with the Kingdom of Dust. The problem of food supply is becoming a serious one for mankind. We have been lavishly using the guano, phosphates, and other fertilizers that nature has given us, along with other priceless heritages such as wood and coal. The time is fast approaching when we shall either have to face starvation or else evolve some new source of food supply. Every day the problem becomes more insistent. What is the solution? Clearly we must wrest from nature one of her simplest and yet most carefully guarded secrets. We must go down in the dust, study the ultimate atoms that compose it, and learn how nature combines a bit of soot and a few raindrops, thereby giving us that wonderful substance, sugar. We must learn how she manufactures that life-sustaining compound, albumen, from carbon, hydrogen, oxygen, nitrogen and a trace of sulphur. Her chemical magic, her marvelous constructions of complex molecules from simple atoms, her power to change the stone into bread, are secrets that lie hidden somewhere within the mighty Kingdom of Dust.